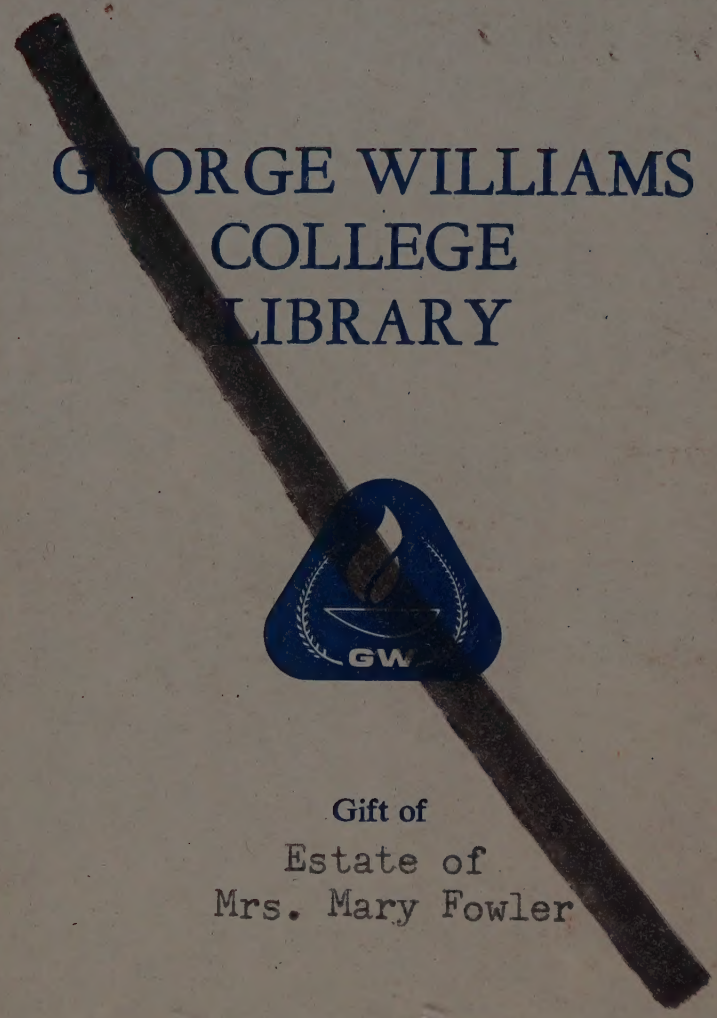
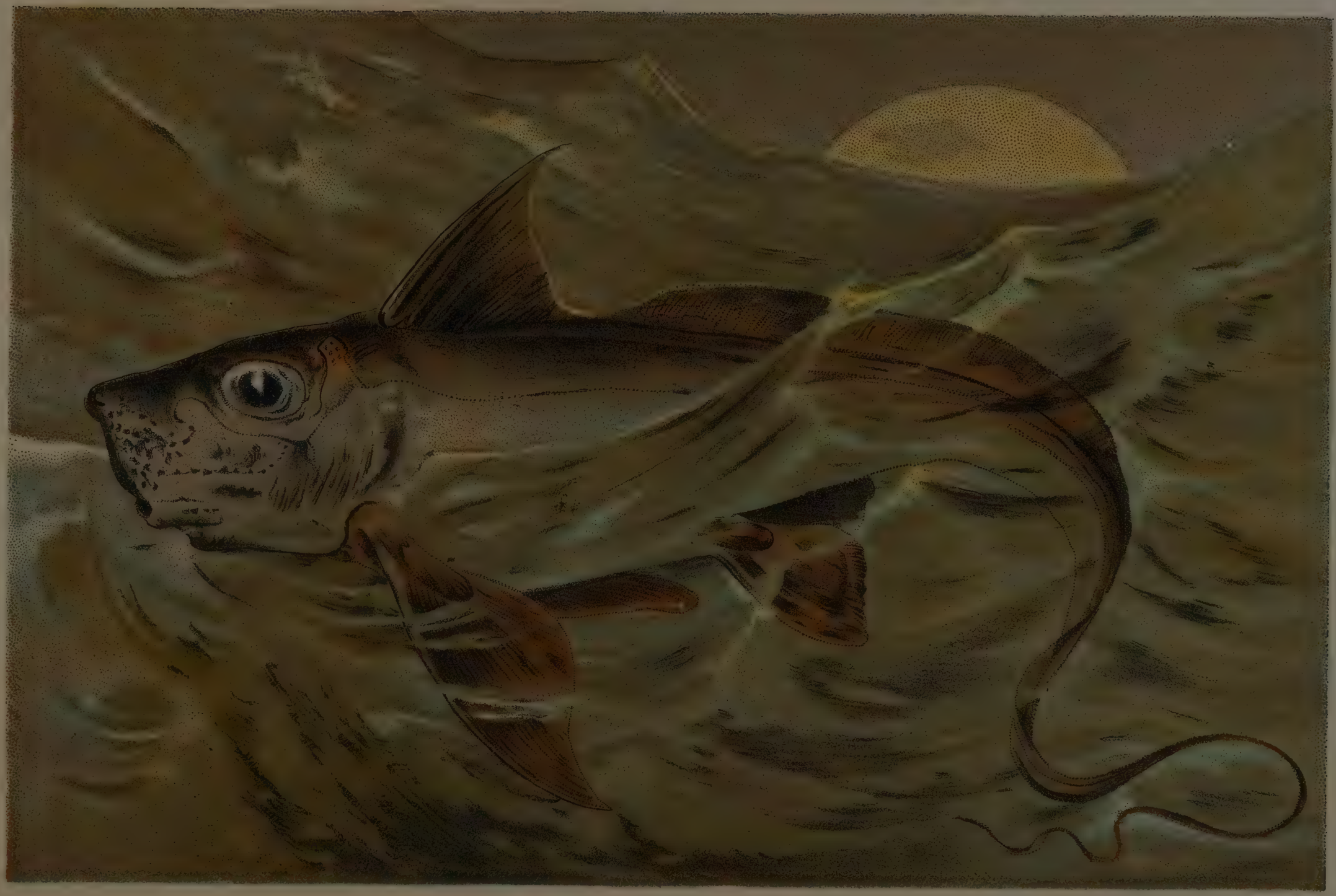
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"WILD ANIMALS I HAVE KNOWN," ETC.

ILLUSTRATED WITH
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SKELETONS OF PRIMEVAL SALAMANDERS.
(Much enlarged.)

Protriton, A, and *Pelosaurus*, B.—From Credner.

CHAPTER III

THE PRIMEVAL SALAMANDERS—ORDER LABYRINTHODONTIA

THE remaining amphibians are extinct, and form an order mainly characteristic of the upper Palæozoic and Triassic periods, but also lingering into the Jurassic. They derive their name of Labyrinthodonts from the complex structure of the teeth of the higher forms; these displaying a peculiar pattern, caused by infoldings of the outer layer, which penetrate nearly to the centre of the crown in festooned lines. Most of these creatures have the general form of a salamander, with the front limbs shorter than the hinder pair; the latter having always five toes, although in the former the number may be reduced to two. Their most characteristic feature is, however, to be found in the structure of the skull, in which the bones are generally covered with a pitted or radiated sculpture, somewhat similar to that of crocodiles. From the following figure of the skull of the mastodonsaur, it will be seen that the whole of the upper surface behind the sockets of the eyes is covered by a complete bony roof, extending continuously from the bone marked *P*, which immediately covers the brain cavity to the sides of the hinder part of the jaws (*QJ*), whereas in all the modern salamanders this region is more or less open. This roofed skull of the primeval salamanders presents an approximation to the

earlier fishes; and a resemblance to that group is also shown by the paired supraoccipital bones (*SO*), which in all the higher Vertebrates are fused together. Nearly all these salamanders are further distinguished by having the chest protected by three sculptured bony plates, one of which is central while the other two are lateral; the position of these plates being shown in our figure of the skeleton, where they are seen on the lower surface of the body, immediately behind the head, underlying the backbone and ribs. Besides this armor, some species had the whole of the under surface of the body protected by a series of bony scales, arranged in a chevron pattern; while in a few instances similar scales also invested the upper surface of the body. The majority of the members of the order had the vertebræ of the backbone in the form of simple doubly-cupped discs, similar to those of fishes; but in some of the most primitive types, each vertebra consists of four distinct pieces, namely, a single basal piece (*i*), a pair of lateral pieces (*pl*), and a single arch and spine (*s*). Among some reptiles the basal piece remains between two adjacent vertebræ as the intercentrum; but in the higher forms the other elements coalesce. Since a similar type of vertebra occurs in certain extinct fishes, we have in this structure another bond between the latter and the primeval salamanders. Brief reference must also be made to the small aperture in the roof of the skull of the primeval salamanders in the bone marked *P*, since this corresponds to one in the skull of the tuatera lizard of New Zealand. In that animal the aperture overlies the rudiment of an eye sunk deep down in the brain and now totally useless, but probably functional in the tuatera's ancestors. The large size of the aperture in the primeval salamanders suggests that the central eye may still have been capable of receiving impressions of light, although we may have to go back to earlier forms before it was of any functional importance as an organ of vision. As in many existing amphibians, teeth frequently occur on the bones of the palate as well as in the margins of the jaws. Another feature of the skulls of many members of the order is the presence of what are called mucous canals in the bones of the upper surface, as shown both in the above



SKULL OF THE MASTODONSAUR, WITH THE SCULPTURE OMITTED.
(About one-eighth natural size.)

SO. supraoccipital; *Ep.* epiotic; *P.* parietal; *Sq.* squamosal; *ST.* supratemporal; *QJ.* quadratojugal; *Ju.* jugal; *Pt.* postfrontal; *PtO.* postorbital; *Fr.* frontal; *PrF.* prefrontal; *L.* lachrymal; *Na.* nasal; *Mx.* maxilla. The premaxilla has no letter.



TWO VERTEBRÆ OF A PRIMEVAL SALAMANDER.

prz is the anterior and *ptz* the posterior end.

and the accompanying figure; these canals also occurring in certain fishes. So far as can be ascertained, both external and internal gills generally disappeared in the adult. Varying from the size of a small newt to that of a crocodile, the primeval salamanders are of especial interest to the evolutionist, as it is pretty certain that not only are they the descendants of primeval fishes, but that they are the ancestors both of the modern Amphibians and the extinct Anomodont Reptiles. And it is probable that Mammals have originated, either directly from them or from a lost group intermediate between them and the Anomodont Reptiles. They appear to have been spread over the whole globe, and they have been divided into several subordinal groups. Among these the highest are the true Labyrinthodonts, typically represented by the gigantic *Mastodonsaurus* and the somewhat smaller *Metoposaurus* of the Trias. These were crocodile-like animals, generally with disc-like vertebræ in the adult, the teeth more or less plicated, and the surface of the skull marked with sculpture and mucous canals. In the Permian *Archegosaurus*, the vertebræ were, however, of the complex primitive type. The Gilled Labyrinthodonts, as represented by *Protriton* and *Pelosaurus*, are a group of much smaller forms, characterized by their barrel-shaped vertebræ, pierced by a remnant of the canal of the primitive notochord; short and straight ribs, articulating by a single head; simple teeth, and the absence of ossification in the occipital region of the skull, as well as in the wrist and ankle joints; a further point of distinction being the development of internal gills in the young. The Permian and Carboniferous Snake-like Labyrinthodonts are characterized by the snake-like form of the body, and the apparent absence of limbs. The vertebræ were elongated and without spines, while the ribs were slender and barbed like those of fishes, and the teeth smooth and simple. Probably the external gills persisted throughout life. In Britain the group is represented by the small *Dolichosoma*; but *Palæosiren* of Bohemia is estimated to have been over forty feet long. If these creatures prove to be the ancestors of the worm-like Amphibians, it would show that the latter are distinct from the newts and salamanders. The Microsauria include small lizard-like forms, such as *Ceratoerpetum* and *Hylonomus* from the Carboniferous of Europe and Nova Scotia, which appear more highly organized than the preceding, and thus connect the Amphibians with the Beaked Reptiles. Their vertebræ are long and constricted, with traces of the notochord; the ribs are generally long, curved, and two headed; the teeth have large central pulp cavities, but no plications; the occiput is ossified, but the wrist and ankle are either ossified or cartilaginous, and in some cases the back is covered with bony scales. In several forms the bony scales on the under surface are so slender as to assume the appearance of abdominal ribs like those of the Beaked Reptiles.



SKULL OF THE METOPOSAUR.
(One-third natural size.)



FISHES

CHAPTER I

General Characteristics—Class Pisces

Although in popular language lampreys are included among fishes, while until quite recently the lancet was very generally placed by zoologists in the same class, it now seems preferable to make each of these the representative of a distinct class, and the true fishes can consequently be defined with greater precision. In this somewhat restricted sense fishes may be described as cold-blooded vertebrate animals, adapted for a purely aquatic life, and breathing almost invariably by means of gills alone. They have a heart consisting generally of only two chambers (three in the lungfishes); the limbs, if present, are modified into fins; there are unpaired median fins, supported by fin rays; and, as in all the higher classes, the mouth is furnished with distinct jaws. The skin may be either naked, or covered with scales or bony plates. As a rule, fishes lay eggs; and the young do not undergo a distinct metamorphosis.

With the Tailed Amphibians the class is very closely connected by means of the lungfishes, which are furnished not only with internal gills, but likewise with functional lungs, and during the early part of their existence with external gills; while these fishes also differ from the other members of the class in that the nostrils communicate posteriorly with the cavity of the mouth, as in the higher Vertebrates. Although the bony fishes of the present day form a specialized side branch, which

has lost many of the characteristics common to the two classes, it will be evident that Fishes and Amphibians are very closely-allied groups; the latter of which has been directly derived from the former. Geologically, fishes are older than any of the classes hitherto described, their fossil remains occurring in strata belonging to the upper part of the Silurian division of the Palæozoic epoch.

The form of a typical fish is so well known that it will be quite unnecessary to describe it; and it may be mentioned that this typical form, which is the one best adapted for progress through water, is very general among fresh-water fishes, although the eels constitute an exception in this respect. Much greater diversity exists, however, among the marine representatives of the class; and we may cite as extreme types a shark, a flat fish, a ribbon fish, and a globe fish.

Classification

The structure of the skeleton, both external and internal, being of the utmost importance in the classification of fishes, it is essential that the attention of the reader should be more fully directed to this point than has been done in the case of the higher Vertebrates. It should first be mentioned that fishes are divided into four subclasses, namely, the Lungfishes or Dipnoi; the Chimæroids or Holocephali; the Bony Fishes and Ganoids or Teleostomi; and the Sharks and Rays or Elasmobranchii. These may be further subdivided into orders as follows:

1. Lungfishes — Subclass DIPNOI.
   - (1) True Lungfishes — Order SIRENOIDEI.
   - (2) Berry-Boned Fishes — Order ARTHRODIRA (extinct).
2. Chimæroids — Subclass HOLOCEPHALI.
3. Bony Fishes and Ganoids — Subclass TELEOSTOMI.
   - (1) Fan-Finned Fishes — Order ACTINOPTERYGII.
   - (2) Fringe-Finned Ganoids — Order CROSSOPTERYGII.
4. Sharks and Rays — Subclass ELASMOBRANCHII.
   - (1) Acanthodians — Order ACANTHODII (extinct).
   - (2) Fringe-Finned Sharks — Order ICHTHYOTOMI (extinct).
   - (3) True Sharks and Rays — Order SELACHOIDEI.

External Skeleton

In regard to the external skeleton, the most characteristic type takes the form of scales. When these overlap and their posterior border is entire, such scales are termed *cycloid*, but when serrated, *ctenoid*. The external skeleton may, however, take the form of plates or granules, which in the chimæroids and sharks and rays are generally isolated, and have a structure precisely similar to that of teeth, consisting of a base of ivory or dentine capped with enamel. The so-called *ganoid* scales, like those of the bony pike, are, on the other hand, quadrangular, and often connected by a peg and socket arrangement; they are formed of true bone capped with an enamel-like substance termed *ganoin*, and true bone likewise occurs in the plates of the sturgeons. A series of specially modified scales, running along the sides of many fishes, constitute the so-called *lateral line*, which is partly connected with the supply of mucus; and certain large V-shaped scales on the borders of the fins of many extinct bony fishes are known as *fulcra*. The *fin rays*, which also come under the designation of dermal structures,



SKELETON OF PERCH.

1. frontal; 2. prefrontal; 3. ethmoid; 4. postfrontal; 5. basioccipital (concealed); 6. parasphenoid; 7. parietal; 8. supraoccipital; 9. paroccipital; 10. exoccipital; 11. alisphenoid (concealed); 12. mastoid; 13. squamosal; 14. orbitosphenoid; 15. presphenoid (concealed); 16. vomer (hidden by 19); 17. premaxilla; 18, maxilla or upper jawbone; 19, 19′. infraorbital ring; 20. nasal; 21. supratemporal; 22. palatine (concealed); 23. hyomandibular; 24. ectopterygoid; 25. entopterygoid; 26. quadrate; 27. metapterygoid; 28. opercular; 29. stylohyal (concealed); 30. preopercular; 31. symplectic; 32. subopercular; 33. interopercular; 34. dentary; 35. articular; 36. angular; 37. hyals (concealed); *a*. vertebræ; *b*. confluent tail vertebræ; *c*. transverse processes; *d*. inferior arches and spines of tail vertebræ; *e*. ribs; *f*. barbs of ribs; *g*. superior arches and spines of vertebræ; *h*. anterior interspinals; *i*. posterior interspinals; *k*. fin rays of anterior dorsal fin; *l*. hard, and *m*. soft rays of hinder dorsal fin; *n*. *o*. hard and soft rays of caudal fin; *p*. interhæmal spines; *q*. interspinals of anal fin; *r*, *s*. hard and soft rays of anal fin; *A*. post-temporal; *B*. supraclavicular; *C*. clavicular; *D*. coracoid; *E*. scapula; *F*. basals; *G*, *H*. rays of pectoral fin; *I*, *K*. postclavicular; *L*. pelvis; *M*, *N*. hard and soft rays of pelvic fin.

are shown in the skeleton represented on p. 2684, and occur in both the median, and paired fins, of which the names are also given in the same illustration. In the median fins the bases of these rays articulate with the *interspinal bones*, or, in clasmobranchs, with the *radial cartilages*. The first rays of the pectoral and dorsal fins may be developed into long spines, having the same structure as teeth.

Internal Skeleton

In the internal skeleton the backbone is divisible only into a trunk and caudal moiety. In the fringe-finned ganoid fishes the primitive notochord persists, although it may be partly surrounded by rudimental arches; while in the sharks and higher bony fishes the column is divided into segments, forming vertebræ with doubly-cupped bodies. In sharks and rays the arches and bodies of the vertebræ remain separate, but in the other groups they are fused together; in the tail, as shown in our figure of the skeleton of the perch, there is also an inferior arch and spine to each vertebra. In the more primitive fishes the notochord is continued to the hinder extremity of the body, where it is surrounded symmetrically by the rays of the caudal fin; this type, which is shown in the accompanying figure of the skeleton of an extinct fringe-finned shark, being termed the *fringe-tailed*, or *diphycercal*. Whereas in some fishes with this type of tail the fringes on the upper and lower portions of the caudal fin are of nearly equal depth, in others the lower fringe of rays becomes somewhat deeper than the others, and a further development of this inequality results in the partially-forked or *heterocercal* tail of the modern sharks and sturgeons, where the end of the backbone is bent upward into the longer superior lobe of the tail, the lower lobe of which is formed exclusively of rays. The lungfishes and sharks have never advanced beyond one or other of these types; but the bony fishes and ganoids, which started with the primitive fringed lobate type, by a gradual shortening of the central part of the tail fin, accompanied by an increasing development of the rays on its lower side, have evolved the completely-forked or *homocercal* tail of the perch, in which, as shown in the figure, the backbone stops short of the fin rays, and ends in an expanded, unsymmetrical extremity, from which these rays are given off in a fan-like manner, so as to produce an appearance of perfect symmetry in the whole structure.



SKELETON OF EXTINCT FRINGE-FINNED SHARK, SHOWING DIPHYCERCAL TAIL.—From Fritsch.

Turning to the limbs, or paired fins, we find that while in the existing elasmobranchs there are no membrane bones (as the elements of the skeleton not formed from primitive cartilage are termed), in the higher bony fishes the pectoral girdle, as shown in the figure on p. 2684, comprises a scapula and a coracoid, flanked by a series of membrane bones, known as the *post-temporal*, *supra-clavicular*, *clavicular*, and *postclavicular*. The pelvis is generally absent; and is never highly developed. In all the cases the basal and radial bones of the pectoral fins articulate directly with the pectoral girdle, so that there are no segments corresponding to the arm and fore-arm of the higher Vertebrates. In the paired fins the structure is very similiar to that of the tail; and a similar transition from a fringed to a fan-like type may be traced as we pass from the primitive to the specialized forms. For instance, in the figure of the perch's skeleton on p. 2684, we may notice that the paired fins are formed of a number of hard rays spreading out in a fan-like manner from a single point of origin; and the same general type obtains in the existing sharks and rays. In certain extinct sharks, like the one of which the skeleton is shown on p. 2685, as well as in the lungfishes and the fringe-finned ganoids, the pectoral fins have a long central lobe running for some distance up the middle, and completely covered with scales (where these are developed), while the rays of these fins form a kind of fringe radiating on all sides from the central lobe. The skeleton of such a fin, which is known as an *archipterygium*, consists of a long cartilaginous axis, composed of a number of joints, gradually decreasing in size from the base to the extremity, as shown in the figure on p. 2687. From one or both sides of such joints there are given off a number of oblique smaller jointed rods, terminating in the fine rays forming the free edges of the fins. How different is the structure of this fin from that of the higher bony fishes will be apparent by comparing the accompanying figure with that of the skeleton of the perch on p. 2684. In the lungfishes this primitive type of fin has persisted to the present day; in the sharks it has now totally disappeared; while among the bony fishes and ganoids, in the latter of which it was the universal type at the period of the Old Red Sandstone, it now only remains in a modified form in the bichir of the Nile, having been developed in the modern bony fishes into the fan type. It may be mentioned that the latter modification of fin is obviously the one best adapted for quick-swimming fishes, the fringe-finned type partaking more of



SKELETON OF STURGEON, EXHIBITING HETEROCERCAL TAIL.

the nature of clumsy paddles, and being adapted for slowly-moving forms like the lungfishes, which pass most of their time among the mud at the bottom of rivers.

It must not be supposed, however, that even the fringed type is the most primitive form of fin known, since in an extinct armored shark (*Cladoselache*) from the Carboniferous formation, we meet with what may be called the fold type of paired fins. In these fishes (one of which is figured in the sequel) the pectoral and pelvic fins are placed far apart, but in the same longitudinal line, and are formed of a series of parallel cartilaginous rods arising from an extended base, and projecting at right angles to the body; the pectoral pair being considerably the larger. Assuming that fishes originally possessed on each side of the body a continuous fold of skin, strengthened by parallel cartilaginous rods projecting at right angles, this fold type is exactly what we should expect to find in the evolution of pectoral and pelvic fins, by the disappearance of a considerable portion of the original fold, and the development and basal contraction of the remaining moieties.



SKELETON OF PECTORAL FIN OF AN EXTINCT FRINGE-FINNED SHARK.
(From Fritsch.)

Although the structure of the skull is of the highest importance in the classification of fishes, our remarks on this subject must be very brief. In the skulls of the higher bony fishes the original cartilaginous cranium, which persists in the sharks, is overlain by a number of membrane bones, the names and position of which are indicated in the figure of the perch's skeleton on p. 2684. Among these the *pterotic* and *sphenotic* are peculiar to the class, and there is always a large *parasphenoid* underlying the base of the skull. The intervention of the elements known as the *hyomandibular* and *symplectic* between the squamosal and the quadrate is unknown elsewhere, although it is by no means universal among fishes. Among other bones may be mentioned the *infraorbital ring* beneath the eye; as well as the *preopercular*, *subopercular*, *interopercular*, and *opercular*, collectively constituting the gill cover or *operculum* of the bony fishes. In the *gill* (or *branchiostegal*) *membrane* which joins with the gill cover in closing in the gill chamber, there may be developed a number of *gill* (or *branchiostegal*) *rays;* but these may be partially or entirely replaced by *jugular plates*, occupying the space between the two branches of the lower jaw. It will be unnecessary to mention by name the various bones constituting the *hyoid arch*, which is attached to the inner side of the hyomandibular by the *stylohyal*, and extends forward to support the tongue; and it will suffice to state that behind this arch are situated the *branchial* or *gill arches*, to the inner margins of which are attached the spine-like gill rakers. In the lower jaw or mandible, there is usually both a *dentary* and an *articular* piece; but an *angular*, and more rarely a *splenial* or *coronoid* element may likewise be developed.

Teeth

The teeth of fishes present a greater degree of variation than is found among any other class of Vertebrates. While in some cases they may be totally wanting, in others they may be developed on all the bones of

the mouth, and even on the hyoid bones and gill arches; and they may be attached only to the membrane lining the cavity of the mouth. Frequently they are welded to the underlying bone or cartilage by a broad basis; but, as in the saw fishes, they may be emplanted in distinct sockets. Usually the coating of enamel is very thin; and the ivory, or dentine, is more vascular than in the other classes. In rare instances the ivory may be penetrated by branching prolongations from the central pulp cavity, as well as by similar infoldings from the exterior, thus producing a structure similar to that obtaining in those of the primeval salamanders. As a general rule the teeth are being constantly renewed throughout life, but in a few instances a single set persists.

Coloration

In beauty, variety, and changeability, the colors of fishes cannot be exceeded by those of any of the other vertebrate classes; metallic tints and almost all the colors of the rainbow being very commonly displayed, while the beauty of the coloration is often enhanced by the rapid changes it undergoes. In many cases the coloration is of a protective nature. An example of this is afforded by the coloring of the upper surface of many flat fishes, such as flounders, which exactly harmonizes with the tints of the sea bottom on which they dwell; while another equally marked instance presents itself in the case of so-called pelagic fishes, like the mackerels and flying fish, which live near the surface of the sea, and have the under parts silvery white, and the back mottled with dark green and black. When viewed from below against the light sky such a fish is practically invisible, while it is equally inconspicuous when seen from above among the dark waters.

Soft Parts

The body of fishes is made up of a great lateral muscle on each side, divided into a number of segments corresponding with the vertebræ, and also separated into a dorsal and ventral moiety by a median longitudinal groove. On its surface the lateral muscle is marked by a number of white zigzag stripes, generally forming three angles, of which the middle one is directed forward; these stripes being formed by the edges of the tendinous divisions between the segments. Generally the muscles are glistening white in color; but in some instances they are "salmon-colored," this tint being due to the coloring matter of the crustaceans on which such fish subsist, which is turned red by the action of the digestive fluids in the same manner as by boiling. The electric organs possessed by certain fishes are considered to be probably formed from specially developed muscles. With regard to the brain, it will suffice to say that it is of an exceedingly low type; and that the ear lacks the tympanum and tympanic cavity of the higher classes. In the bony fishes there occurs at the base of the brain cavity a sac, often divided into two unequal-sized chambers, and each of which contains an ear bone or *otolith* of very dense structure. These otoliths, which are very constant in form in the different groups, frequently have scalloped margins and groove-like markings, formed by the ramifications of the auditory nerve. The tongue is frequently absent, and if present is of very simple structure and incapable of protrusion; and since fishes generally bolt their food without mastication, it is probable that they have little, if any, sense of taste. With regard to the digestive organs, it will suffice to mention that in the sharks, rays, and chimæroids the intestine for a large portion of its length is provided with a spiral valve, a similar structure occurring in the ichthyosaurian reptiles.

The gills of sharks, rays, and chimæroids are contained in pouches, usually five in number on each side; each pouch opening externally by a slit, and also communicating by a separate aperture with the pharynx. In the embryos filamentous gills protrude externally from the slits. The *spiracles* found on the top of the head in the groups mentioned are the external openings of a canal leading on each side into the pharynx, and represent what is known as the first visceral cleft in the embryo. In the bony fishes the gills, which are generally four in number, lie in one undivided cavity on each side of the head, supported by their gill arches, and covered over by the gill cover, which is open behind. In ordinary respiration the water is taken in by the mouth, and by a kind of swallowing action driven over the gills, after which it is expelled by the gill opening. Allusion must be made in this place to certain organs known as false gills, or *pseudobranchiæ*. These are remains of a gill situated in front of the persistent ones, which was functional during embryonic life, but in the adult appears merely as a plexus of blood vessels. Although the majority of fishes breathe in the manner indicated above, in many forms this is by no means the sole method of respiration. On this subject Day observes that respiration in fishes is carried out normally, either by their using the air which is held in water to oxygenate the blood at the gills, or "by taking in atmospheric air direct, which is employed at a special organ, where it oxygenates the blood, which can be returned for use into the general circulation without going through the gills. The true amphibious fishes respire by the latter method. No doubt we observe that fishes which normally oxygenate their blood solely at their gills do rise to the surface in very hot weather, when the water is foul or insufficiently charged with air, and take in air by the mouth; likewise we find that those which mainly take in atmospheric air direct by the mouth may, to a certain extent, be able to use their gills. If fishes having these two different modes of respiration are placed in a globe of water, across which a diaphragm of net is inserted below the surface, so as to prevent their obtaining access to the atmosphere, those of the class which oxygenate their blood at the gills are unaffected, whereas those which have accessory breathing organs and take in air direct die from blood poisoning."

One of the most characteristic organs of fishes is the air bladder, which is a long sac filled with gas lying in the abdominal cavity, which may be either completely closed, or may communicate with the alimentary tract by means of a duct. As it is susceptible of compression, its usual function appears to be to regulate the specific gravity, or to change the centre of gravity of the fish; but in the lungfishes it assumes the characteristics and functions of the lungs of the higher Vertebrates, to which, indeed, it corresponds.

Reproduction

Although in the few fishes which produce living young, as well as in the sharks and rays, an actual connection takes place between the two sexes, in the great majority of the class the ova are deposited by the female, after which they are fertilized by the male. The bony fishes lay numerous eggs which are of relatively-small size and may be extremely minute, those of the eel being almost microscopic; but there is a considerable degree of variation in this respect. In the herring the number of eggs in the "roe" has been estimated at twenty-five thousand, and in the cod at over nine millions. Only in a catfish

(*Aspredo*), where they are pressed into the skin of the under surface of the body, and a pipefish (*Solenostoma*), where they are carried in a pouch formed by the coalescence of the broad pelvic fins with the skin of the body, is the female known to take any care of her eggs after spawning. Among the bony fishes there are, however, several instances where the young are more or less carefully tended by the male parent; some, like the sticklebacks, building a nest, while others, like certain pipefishes, have an abdominal pouch in which the eggs are hatched. The eggs of sharks, rays, and chimæroids differ remarkably from those of bony fishes, being large in size, few in number, and laïd singly instead of in masses. They are invested in a hard horny envelope, which is generally oblong in form, with the four corners produced, and frequently elongated into tendrils by means of which the egg is moored to some foreign substance. The males of these fishes are armed with organs known as *claspers*, which are partially ossified processes arising from the pubis, and are evidently connected with the function of reproduction. The young of many fishes differ markedly from the adult; and certain peculiar creatures with long ribbon-like bodies and small heads, for which the name of *Leptocephali* has been proposed, are believed to be the young of littoral fishes which have been carried out to sea, where they have undergone an altogether abnormal development. The changes which take place in the flat fishes during development may be more conveniently noticed under the heading of that group. Although male and female rays differ remarkably from one another in the structure of their teeth, while both in this group and in the sharks and chimæroids the males are distinguished by the possession of the aforesaid claspers, there is generally but little sexual difference among fishes. In the bony fishes, however, the females are larger than the males; among the cyprinodonts the difference between the two being occasionally as much as six times.

Tenacity of Life

Fishes exhibit a remarkable degree of difference in regard to their power of bearing changes from their normal environment. On this subject Dr. Günther writes that, "some will bear suspension of respiration — caused by removal from water, or by exposure to cold or heat — for a long time, while others succumb at once. Nearly all marine fishes are very sensitive to changes in the temperature of the water, and will not bear transportation from one climate to another. This seems to be much less the case with some fresh-water fishes of the temperate zone; since carp may survive after being frozen in a solid block of ice, and will thrive in the southern parts of the temperate zone. On the other hand, some fresh-water fishes are so sensitive to a change in the water that they perish when transferred from their native river into another apparently offering the same physical conditions. Some marine fishes may be abruptly transferred from salt into fresh water, like sticklebacks; others survive the change when gradually affected, as many migratory fishes; while others, again, cannot bear the least alteration in the composition of the salt water (all pelagic fishes). On the whole, instances of marine fishes voluntarily entering brackish or fresh water are very numerous, while fresh-water fishes proper but rarely descend into salt water."

The foregoing remarks lead naturally to the subject of the distribution of fishes, a subject which the limits of space compel us to dismiss with a few sentences.

Distribution In the first place, we find that many marine fishes have a much less wide geographical distribution than might at first sight be expected; while, on the other hand, we find families and genera, and even species, of fresh-water fishes inhabiting widely separated areas of the earth's surface. The primary division into fresh-water and marine fishes does not form such a sharply defined boundary as is commonly supposed, the transition being formed by the brackish-water types, species or even individuals of which can accustom themselves to live in either salt or fresh water. Then, again, we have certain essentially fresh-water fishes, like the salmon and some kinds of catfish, which pass a certain period of their existence in the ocean; while, on the other hand, some marine forms, such as sturgeons, periodically ascend rivers for the purpose of spawning. To a certain extent such habits will help to explain the occurrence of peculiar families of fresh-water fishes (such as the chromids of Africa, South America, and India) in widely-separated areas, although this must probably be supplemented by dispersal from a common northern centre.

After the separation of the fresh-water and brackish-water types, the marine fishes are divided by Dr. Günther into a littoral, a pelagic, and a deep-sea group, although here, again, no hard-and-fast lines can be drawn. The littoral or shore fishes are those found in the immediate neighborhood of land or sunken shoals, the majority living close to the surface, and very few descending as deep as three hundred fathoms. Their distribution is determined not only by the temperature of the surface water, but likewise by the nature of the neighboring land, and its animal and vegetable products; some of these fishes being suitable to inhabit flat coasts with muddy or sandy bottoms, while others frequent rock-bound shores where the water is deep, and others, again, congregate round coral reefs. Cod, rays, and flatfish are well-known examples of this group. Pelagic fishes, such as tunnies, flying fishes, swordfishes, and sunfishes, inhabit the superficial layers of the open ocean, approaching the shores only by accident, or in some cases in search of food, or for the purpose of spawning. Dr. Günther writes that, "with regard to their distribution, they are still subject to the influences of light and the temperature of the surface water; but they are independent of the variable local conditions which tie the shore fish to its original home, and therefore roam freely over a space which would take a fresh-water or shore fish thousands of years to cover in its gradual dispersal. Such as are devoid of rapidity of motion are dispersed over similarly large areas by the oceanic currents, more slowly than, but as surely as, the strong swimmers."

In marked contrast to the last are the deep-sea fishes, inhabiting the abyssal depths of the ocean, where they are undisturbed by tides or currents, and live for the most part in total darkness; their organization, in consequence of the great pressure of the medium in which they live, preventing them from coming to the surface in a healthy condition. From the similarity in the physical conditions of the ocean depths in all parts of the world, there seems no reason why a single species of deep-sea fish should not range from the Equator to the Poles; and the abyssal fauna is probably more or less nearly the same throughout the globe. These fishes belong for the most part to pelagic families, and especially to such types as are of nocturnal

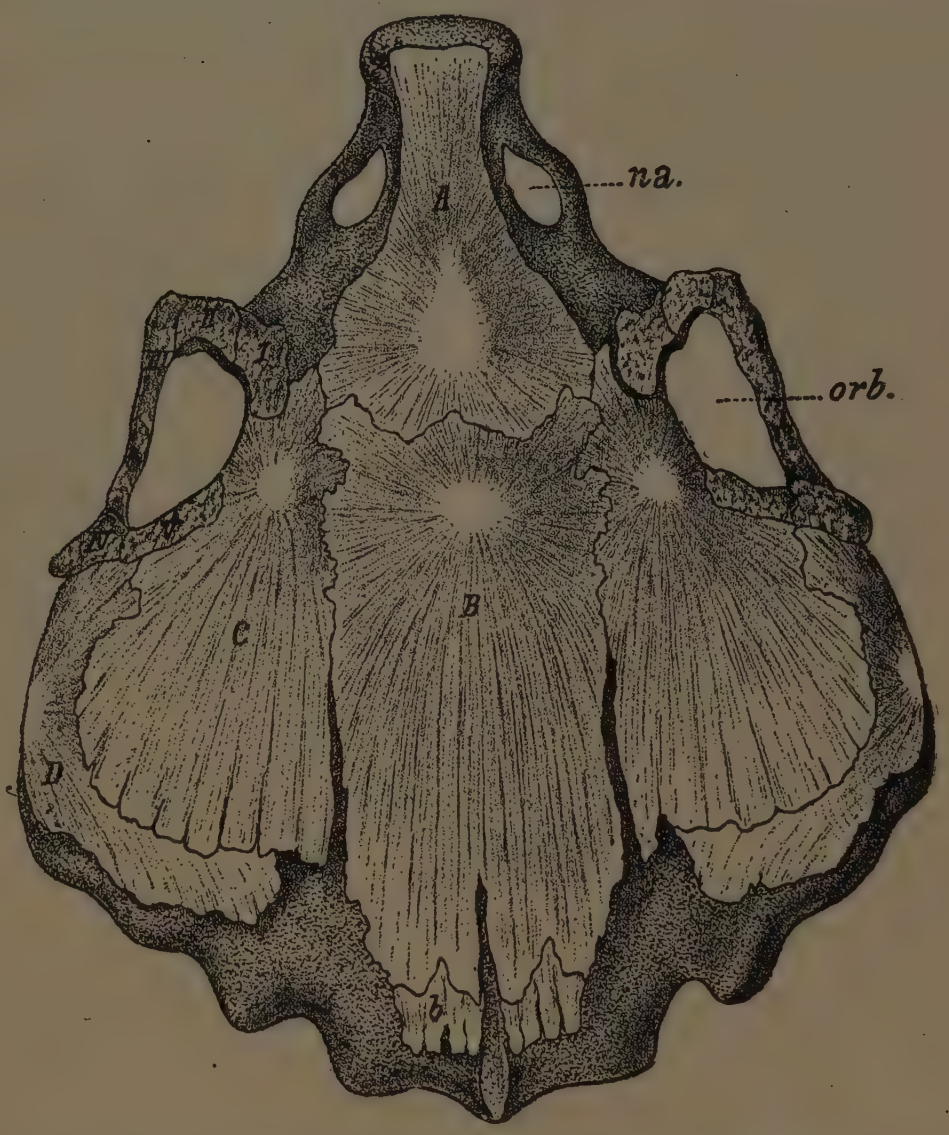
habits; and are characterized by their generally black or silvery color, although in a few instances the fin rays and certain filaments are scarlet. Writing of those fisher, Dr. Günther observes that, "the organ of sight is the first to be affected by a sojourn in deep water. Even in fishes which habitually live at a depth of only eighty fathoms, we find the eye of a proportionately larger size than in their representatives at the surface. In such fishes the eyes increase in size with the depth inhabited by them, down to the depth of two hundred fathoms, the large eyes being necessary to collect as many rays of light as possible. Beyond that depth, small-eyed as well as large-eyed fishes occur; the former having their want of vision compensated by tentacular organs of touch, while the latter have no such accessory organs, and evidently only see by the aid of phosphorescence. In the greatest depths occur blindfishes, with rudimentary eyes, and without special organs of touch. Many fishes of the deep sea are provided with more or less numerous, round, shining, mother-of-pearl-colored bodies, embedded in the skin. These so-called phosphorescent or luminous organs are either bodies of an oval or irregularly elliptical shape placed in the vicinity of the eyes, or smaller globular bodies arranged symmetrically in series along the sides of the body and tail." That the function of these bodies is to produce phosphorescent light may be considered certain; and it is probable that both the tentacles and the whole surface of the bodies of these extraordinary fish are also phosphorescent. Not the least remarkable feature about the carnivorous deep-sea fishes is the enormous size of their stomachs, which enable them to swallow creatures nearly as large as themselves, drawing themselves over their prey almost after the manner of a sea anemone. Although when brought to the surface deep-sea fishes are soft, flabby creatures, with their scales standing out at right angles, and their eyes starting from their sockets, at their own proper level, under an enormous pressure, their bodies are doubtless as firm and compact as those of ordinary fish. Deep-sea fish certainly live at a depth of two thousand seven hundred and fifty fathoms.

In regard to geological distribution, it has already been mentioned that the oldest true fishes occur in strata of upper Silurian age; such early fishes being sharks. In the succeeding Devonian and Carboniferous periods, the class was abundantly represented, but only by sharks, fringe-finned ganoids, and lungfishes. In the Permian, Triassic, and Jurassic periods chimæroids, as well as the chondrosteous Teleostomi made their appearance; but it was not till the Cretaceous epoch that the higher bony fishes, which are the predominant forms in the Tertiary period and at the present day, were developed. There are fully nine thousand known species of living fishes, while considerably more than one thousand fossil forms have been already described.

CHAPTER II

THE LUNGFISHES AND CHIMÆROIDS—SUBCLASSES DIPNOI AND HOLOCEPHALI

THE first two subclasses of fishes agree with one another, and thereby differ from the remaining two, in the structure of the skull, in which the hyomandibular bone is welded with what is known as the palatopterygoid bar (that is to say, the bones corresponding with the palatines and pterygoids of the higher Vertebates), which is itself firmly united to the cranium proper, so that there is no separate structure for the suspension of the lower jaw. To this type the name of solid-skulled (technically autostylic) fishes may be applied; and it may be noted that this type of structure is essentially the same as that on which the skulls of the Amphibians are formed. In the lungfishes the skeleton is partially ossified, with well-developed membrane bones; the gill clefts are but slightly separated, and open into a single cavity protected by an external cover; and the external skeleton consists of true bony tissue. In the existing members of the group the optic nerves (or those proceeding from the brain to the eyes) simply cross one another, without any interlacing of the constituent fibres; the intestine has a spiral valve; the air bladder is elongated, and performs the functions of a lung; and the nostrils open posteriorly by two apertures into the cavity of the mouth, after the



ROOF OF THE SKULL OF THE AUSTRALIAN LUNGFISH.
A. anterior, and *B*. posterior median plate; *C*. inner, and *D*. outer lateral plate; *na*. nostrils; *orb*. socket of the eyes.
(From Teller.)

manner of the higher Vertebrates. The membrane bones covering the roof of the skull, which are very few in number, cannot be correlated with those of the bony fishes; their mode of arrangement being shown in the accompanying figure. The lungfishes are at the present day represented only by three genera, with but very few species, but they were formerly a very numerous group, which appears to have been on the wane since a very early epoch.

The Existing Lungfishes — Family *Lepidosirenidæ*

The three existing genera of lungfishes may be taken as the typical representatives of an order including several extinct families, and known as the Sirenoidea. Its essential characteristics are that the head is covered with membrane bones; that the main dentition takes the form of large grinding plates, situated on the ptery-



UPPER PALATAL TEETH OF AN EXTINCT LUNGFISH (*Ceratodus*).
(From Teller.)

goid bones in the upper, and on the splenials in the lower jaw; that the body is covered externally with overlapping scales; that the notochord persists throughout life; that the paired fins are of the fringed type; and that none of the fins are armed with spines. The existing forms have but few membrane bones to the skull; no premaxillæ, maxillæ, marginal teeth, or jugular plates; a fringed tail, furnished with a continuous vertical fin; and cycloid scales.

Australian Lungfish

For a great number of years there were known from the Triassic strata of various parts of Europe fish teeth of the remarkable type of the specimen represented in the accompanying figure; and from the fancied resemblance to a deer's antler, presented by these teeth, the name of *Ceratodus* was suggested for the otherwise unknown fishes to which they pertained. Similar teeth were subsequently obtained from Secondary rocks in India and also in South Africa, but it was not until the year 1870 that a fish was discovered in Queensland having teeth of a similar type. Known to the natives, in common with other large fresh-water species, by the name of barramundi, the Australian lungfish (*C. forsteri*) agrees so closely with the extinct forms that it is usually regarded as generically identical. Its mouth is furnished in front with a pair of chisel-like teeth

situated on the vomers, behind which come a pair of palatal teeth of the type of the one shown in the figure, but carrying six complete ridges, and an incomplete seventh; while there are a pair of similar teeth in the lower jaw, carrying only six ridges each. In the living species the teeth of opposite sides are separated by an interval; but in the fossil forms they were in contact, and had fewer ridges. The existing Australian lungfishes, of which two species have been described, are said to attain a weight of twenty pounds, and a length of upward of six feet. The body is elongated and much compressed, with very large scales; the paddle-shaped limbs have very broad fringes; and the flesh is salmon color. From the occurrence of masses of leaves in its stomach it is evident that the Australian lungfish crops the



AUSTRALIAN LUNGFISH.
(One-seventh natural size.)

vegetation with its great teeth, but it is believed that the most important part of its food consists of the small creatures living on and between the leaves of the various water plants. The stories of the fish coming out of the water to the land seem quite unfounded, as are those that it lies dormant during part of the year in cocoons. The female lays her rather large eggs loosely and singly among the vegetation, and in the embryo the fore-limbs make their appearance in about a fortnight, but the hinder pair not before two and a half months. In the course of its development this fish presents marked resemblances to the Amphibians, and also to the lampreys, but it is noteworthy that there is no trace of a sucking mouth, or of external gills.

As might have been inferred from the study of allied extinct forms, the large palatal teeth are formed by the fusion of a number of separate small teeth. According to Dr. Semon, the Australian lungfish is confined to the middle portion of the Burnett and Mary rivers of Queensland. Living among the mud and leaves at the bottom, it rises at intervals to the surface to obtain more complete oxygenation of its blood by the inhalation of atmospheric air into its lungs, although its general breathing is carried on by the gills. A grunting noise sometimes uttered by this fish is probably produced by the expulsion of the air from the lungs when it rises to the surface. Although frequently termed the barramundi—a title apparently properly belonging to a totally different fish (*Osteoglossum*)—it appears that the proper native name of the Australian lungfish is djelleh. The breeding season is at its



SOUTH-AFRICAN MUDFISH.
(One-fifth natural size.)

height in September and October, but lasts from April till the beginning of November; and the eggs, which are enveloped in a gelatinous coat, and are heavier than water, take some ten days to hatch.

South-American Mudfish

The mudfish of the Amazons (*Lepidosiren paradoxa*) is the sole representative of a genus distinguished from the last by the eel-like form of the body, on which the continuous vertical fin extends nearly to the neck, and by the reduction of the limbs to mere tapering filaments owing to the disappearance of the marginal fringe. The vomerine teeth are conical and pointed, and the palatal teeth have strongly-marked cusps supported by vertical ridges. There are five gill arches, with four intervening clefts, but there are no external appendages above the gill opening. In adult males the upper sur-

face of the hind-limb is beset with tufts of tentacle-like papillæ. This mudfish grows to a length of about four feet, and occurs not only in the Amazon and its tributaries, but likewise in the swamps of the Chako country forming the tributaries of the upper Paraguay river. The southern form has been regarded as a distinct species, although the differences are so slight as scarcely to merit such a distinction. These fish feed chiefly on the large mollusks known as ampullariæ, which are found collected in great masses in the Chako swamps; their shells being easily crushed by the powerful teeth of their devourers.



AFRICAN MUDFISH.
(One-third natural size.)

African Mudfish

The African mudfish (*Protopterus annectans*), widely spread over the tropical regions of the continent from which it takes its name, differs from the last in that the filamentous fins retain a small fringe containing rays; as well as in having six gill arches, with five intervening clefts, while there are three small tentacle-like appendages above the small gill opening on each side. In the Gambia river, where they are very abundant, these fishes are in the habit of burying themselves during the dry season, making a kind of nest, in which they pass a period of torpidity. Here they may remain for the

greater part of the year, only resuming their normal aquatic life with the return of the wet seasons. Professor W. N. Parker, who received some specimens in the torpid condition, writes that about a hundred individuals were dug out and packed up in crates still inclosed in the clods of mud. On arrival in Europe the clods were opened, and the fishes placed in a tank in a hothouse. The statement of the natives that the species grows to the almost incredible length of six feet suggests that it must be a very long-lived creature. From the above-mentioned specimens it was found that these mudfishes grow very rapidly, have great vitality, and, although able to sustain fasts, are exceedingly voracious, devouring all the snails, earthworms, and small fish given them, and then killing and eating each other, making it difficult in the extreme to preserve the specimens. They are most active at night, and appear to keep mostly to the shallow water, where they move deliberately about on the bottom, alternately using the peculiar limbs of either side, though their movements do not seem to be guided by any strict regularity. Gray has compared these movements to those of a newt, and several other observers have noticed them. The powerful tail forms a most efficient organ for swimming rapidly through the water. It is well known that this fish comes to the surface to breathe at short intervals, and thus it is evident that the lungs perform an important, if not the chief, part in respiration during the active life of the animal. The air passes out again through the opercular aperture, and the movements of the operculum itself indicate the fact that bronchial as well as pulmonary respiration takes place. Externally, the sexes present no characteristics whatever distinguishing them apart. As in the American species, external gills are developed in the young. As regards the breeding habits of these fishes nothing very definite is known. It is stated, however, that the numerous eggs and embryos are carried about in an elongated gelatinous pouch attached to the sides of the back of one of the parents, although the sex in which these receptacles are developed does not appear to have been ascertained. In conclusion, it may be observed that Professor Parker is of opinion that although the lungfishes present certain resemblances on the one hand to some of the sharks and ganoids and on the other to the lower Amphibians, yet they appear so distinct from both that he thinks they ought to be removed from the fishes to form a class by themselves.

Extinct Lungfishes

In the Palæozoic epoch lungfishes formed an abundant group, which may be divided into three families. Of these the Carboniferous and Permian *Ctenodontidæ*, as represented by *Ctenodus* and *Sagenodus*, resemble the existing forms in the absence of marginal teeth to the jaw and of jugular plates on the throat, but differ by the numerous membrane bones of the skull; the caudal fin being of the fringed type, and the scales cycloidal. The type genus which includes species of five feet in length, takes its name from the comb-like structure of the ridged palatal teeth. The second family, *Phaneropleuridæ*, differs from the last in the presence of both marginal teeth and jugular plates; the typical genus *Phaneropleurum*, including small species from the Devonian. In the *Dipteridæ*, as represented by the Devonian *Dipterus* and *Palædaphus*, jugular plates are present, but there are no marginal teeth, and the tail is of the heterocercal

type; the skull having numerous membrane bones. The teeth are very similar to those of the Australian lungfish, but may be ornamented with small ridges and pustules.

The Berry-bone Fishes — Order Arthrodira

The extraordinary Palæozoic group typically represented by the berry-bone fish (*Coccosteus*) of the Scottish Devonian differs from the true lungfishes in that in place of scales the fore part of the body is protected by large bony plates, of which one pair is articulated by a hinge to the hinder part of the skull, which is likewise invested with bones bearing a similar pustular or berry-like sculpture. The fore-limbs were either rudimental or wanting; but a pair of pelvic fins were developed. Most or all of the forms may be included in the single family *Coccosteidæ;* and among these the typical genus is distinguished by the absence of any pectoral fin, while in the allied *Brachydirus* this appendage is represented by a hollow spine. In both these the sockets of the eyes form notches on the sides of the skull; and the same is the case with the gigantic *Dinichthys* of the North-American Devonian. In another group, however, as represented by *Homosteus*, the eye sockets were completely inclosed in the membrane bones with which the head is covered.



PARTIAL RESTORATION OF THE BERRY-BONE FISH.
(From A. S. Woodward, *Cat. Foss. Fishes, Brit. Mus.*)

The Chimæroids — Subclass Holocephali

Represented by three existing marine genera, of which one has three, the second one, and the third two species, and a number of extinct types, the chimæroids form a second subclass, agreeing with the lungfishes in their solid (autostylic) skulls, but differing by the total absence of membrane bones, and their superficial external resemblance to sharks. The skeleton is cartilaginous, with the notochord either persistent or constricted and surrounded by cartilaginous rings, which are sometimes partly calcified; and in the adult the skin is frequently quite naked, although in the young it may bear on the back a series of structures similar in composition to teeth, some extinct forms having plates of the same nature. In the existing members of the group the optic nerves simply cross one another, and the intestine has a spiral valve; while further resemblances to the sharks are shown by the presence of claspers in the males, and also by the large size and small number of the single eggs. The four gill clefts open externally by a single aperture on each side, protected by a fold of skin containing a cartilaginous operculum. The mouth is situated at the extremity of the muzzle, and the teeth on the palate and lower

jaw are molar-like, while there is also a small pair of cutting vomerine teeth in the front of the upper jaw; the whole dentition thus closely corresponding to that of the lungfishes, although there are two pairs of upper palatal teeth, which present certain hardened areas known as *tritors*. The pectoral fins are shortened, without the segmented axis of the lungfishes; and the first dorsal fin may have a movable spine articulated to the spinous processes of the vertebræ. The sides of the body show a lateral line; but there is no air bladder, and the nostrils do not open behind into the cavity of the mouth. It has been suggested that the chimæroids indicate a degenerate group nearly allied to the lungfishes, which have lost the membrane bones of the latter, and acquired a superficial resemblance to sharks.

The ugly fish, to which the name chimæra has been applied (*Chimæra monstrosa*), together with two other existing species, typically represents the family *Chimæridæ*, which alone has survived to the present day. The family is characterized by the presence of a spine to the first dorsal fin, and also of a prehensile spine-like structure on the heads of the males; there are no superficial plates on the skull, and only a single pair of lower teeth. The family, which contains a number of extinct genera, mainly distinguished from one another by the characteristics of the triturating areas on the teeth, dates from the Lias; the typical genus being, however, unknown before the latter part of the Tertiary period. The living chimæras do not probably exceed five feet in length, and have the soft muzzle devoid of an appendage. The dorsal fins occupy the greater part of the back; and the longitudinal axis of the long filamentous tail is nearly continuous with that of the back, its extremity being provided above and below with a long, low fin of the diphycercal type. The common species represented in the annexed colored plate ranges from Europe and Japan to South Africa; while a second occurs on the Pacific coast of North America, and a third off Portugal. The southern chimæra (*Callorhynchus antarcticus*) from the southern temperate seas differs from the preceding genus by the presence of a cartilaginous prominence, ending in a flap of skin, on the muzzle, and likewise by the upward direction of the extremity of the tail, which has no fin on its upper surface. A fossil representative of this genus occurs in the Cretaceous rocks of New Zealand. The third genus, *Harottia*, distinguished by the extreme elongation of the snout, is represented by one species from the Atlantic, and a second from the Pacific. As well-known extinct types of the family we may refer to the Cretaceous and Tertiary genera *Edaphodon* and *Elasmodus;* the former including fishes of gigantic dimensions. The members of the extinct family *Myriacanthidæ*, of the Jurassic rocks, differ by having a few bony plates on the head, and three lower teeth; while the *Squaloraiidæ*, as represented by *Squaloraia* of the Lias, were somewhat ray-like forms, with a depressed trunk and elongated muzzle, and no spines to the dorsal fins. The subclass appears also to be represented in Palæozoic times, the Devonian *Ptyctodus* indicating a family which cannot at present be fully defined.

CHAPTER III

THE BONY FISHES AND GANOIDS — SUBCLASS TELEOSTOMI

FORMERLY the typical bony fishes of the present day were regarded as indicating a primary group (Teleostei) of equal rank with a second one known as the Ganoidei; the latter, containing the American bony pike, and the African bichir, together with a host of extinct genera possessing a similar armor of hard ganoid scales. A fuller study of these and other allied fossil forms has, however, shown the existence of such a complete transition from these so-called ganoids to the typical bony fishes that it has become necessary to include the whole of them in a single subclass, under the title heading this chapter. Although there is still some degree of uncertainty as to the best mode of arranging certain groups of the bony fishes, the following scheme may be temporarily adopted:

1. Order ACTINOPTERYGII — Fan-Finned Group.
   - (1) Suborder PHYSOCLYSTI. { ACANTHOPTERYGII — Spine-Finned Fishes.
   - (2) " LOPHOBRANCHII — Tuft-Gilled Fishes.
   - (3) " PLECTOGNATHI — Comb-Gilled Fishes.
   - (4) " ANACANTHINI — Soft-Finned Fishes.
   - (5) " PHYSOSTOMI — Tube-Bladdered Fishes.
   - (6) " ÆTHEOSPONDYLI — Bony Pike.
   - (7) " PROTOSPONDYLI — Amioids.
   - (8) " CHONDROSTEI — Sturgeons.
2. Order CROSSOPTERYGII — Fringe-Finned Group.

In this wide sense the subclass differs broadly from the two preceding ones in the structure of the skull, which is formed on what may be termed the hinged type (*hyostylic*); that is to say, the palato-pterygoid bar remains separated from the cranium proper, to the hinder part of which it is movably articulated by the intervention of the hyomandibular. The internal skeleton is more or less ossified, with the development of membrane bones on the jaws; the gill clefts are but slightly separated from one another, and are fully protected by an operculum; the membrane bones of the pectoral girdle (that is to say, the scapula, claviculars, etc.) are connected with the hinder part of the skull; and the external skeleton takes the form either of plates of bone or of calcified overlapping scales. In existing forms the eggs are small, numerous, and generally massed together; the two optic nerves may either simply cross one another, or may give off mutually interlacing fibres; an air bladder — with or without a duct — is very generally present, and the intestine may sometimes be furnished with a spiral valve.

This group — Actinopterygii — includes all the bony fishes of the present day, as well as the sturgeons, and is characterized by the fan-like structure of the paired

Fan-Finned Group

fins, in which the proper internal skeleton is abbreviated to make way for the greatly developed dermal fin rays; the caudal fin being of very variable structure. In the branchiostegal membrane, occupying the space between the two branches of the lower jaw, there is always a paired series of transversely elongated rays. The first seven suborders of this order, given in the table on p. 2701, form one great division characterized by the number of dermal rays in the dorsal and anal fins being equal to that of the supporting bony elements, and



PIKE PERCH AND COMMON PERCH.
(One-fourth natural size.)

by the tail being never heterocercal,* but usually either of the abbreviate-heterocercal or homocercal type, although occasionally diphycercal.

Spine-Finned Fishes

In the classification proposed by Professor Cope the first four suborders of the fan-finned group given in the foregoing table are regarded as a single group under the title of Physoclysti, and in common with the tube-bladdered fishes, have the fibres of the optic nerves interlacing,

* In the heterocercal type the upper lobe of the tail is the longer, and the vertebral column is continued up into it; in the abbreviate heterocercal the tail is symmetrical, and the vertebral column complete but bent up into its upper half; in the homocercal type the tail is also symmetrical, but the vertebræ stop short at its base, where the latter ones are aborted into a mass; in the diphycercal form the vertebræ are continued without abortion along the middle line of the symmetrical tail fin.

the intestine without a spiral valve, and the skeleton fully ossified. From the Physostomi, the Physoclystous group are distinguished by the general absence of a duct to the air bladder (when present), by the parietal bones of the roof of the skull being always separated from one another by the intervention of the supraoccipital, and by the pelvic fins being in most cases either thoracic or jugular* in position. Regarding, however, the spine-finned fishes as constituting a separate suborder, they are distinguished, in addition to the foregoing characteristics, by some of the anterior rays of the dorsal, anal, and pelvic fins usually taking the form of strong, unjointed, bony spines. It must, however, be acknowledged that this characteristic is one of but little importance; some of the hairtails (*Trichiuridæ*) scarcely possessing what can be denominated true spines, while these are also wanting in the family (*Scombresocidæ*) to which the flying fishes belong. In all cases the gills are comb-like, the pectoral arch is suspended from the skull, and interclavicles are wanting.

The Perch Tribe — Family *PERCIDÆ*

The first representatives of the spine-finned fishes are the perches, which, with several allied families, belong to a sectional group (*Perciformes*) of the suborder, characterized by the lower pharyngeal bones being generally separate, and the scales usually of the ctenoid type. The preopercular bone of the gill cover has no bony stay connecting it with the eye; the spinous portion of the dorsal fin is well developed; none of the additional rib-like bones known as epipleura are attached to the bodies of the vertebræ; the pelvic fins are thoracic in position, and have usually five (rarely four) branched rays; and the supporting bones (pterygials) of the pectoral fins are longer than broad, and of a more or less distinctly hourglass form. The Perch family, as restricted by Mr. Boulenger, is distinguished by the following characteristics: In the skeleton the anterior vertebræ have no transverse processes, but in the dorsal part of the series all or most of the ribs are attached to such processes. There are two nostrils on each side; the gill membranes are free from the isthmus or space between the two branches of the lower jaw and gill openings; there are four pairs of gills, with a slit behind the fourth; the gill rays or branchiostegals vary from six to eight on each side; more or less fully-developed false gills are generally present; the soft portion of the dorsal fin is not very much more developed than the anal, and the latter has either one or two spines. In common with the two following families, the perches are further characterized by the general presence of a lateral line, continuous from the head to the tail, the usual absence of scales from the median fins, the simple conical teeth, and the absence of barbels round the mouth. In form the body is more or less elongate, compressed, and cylindrical; although rarely it may be slightly compressed. As now restricted, the family includes a dozen genera inhabiting the fresh waters of North America, Europe, and Western Asia; but the members of the genera *Lucioperca* and *Percarina* enter salt water. All are carnivorous.

*They are said to be thoracic when in the same vertical line as the pectoral fins, and jugular when in advance of them.

True Perches The common perch (*Perca fluviatilis*), which is a fish of wide distribution, and one too familiar to require detailed description, is the type of a small genus, agreeing with eight others in the following characteristics: In the head the mucus or slime canals are but moderately or slightly developed on the top and at the sides; and the spinous and soft portions of the dorsal fin are separate. In common with six other genera, the body is more or less compressed; the perches and pike perches being specially distinguished by having usually seven (rarely eight) gill rays; by the premaxillæ or anterior upper jawbones being capable of protrusion, and by the serration of the preopercular bone of the gill cover. As a genus, the true perches are distinguished from the pike perches by the small and uniform size of the marginal teeth, and the close approximation of the pelvic fins. There are teeth on the palatine and vormerine bones, but none on the tongue, and there are thirteen or fourteen spines in the first dorsal fin, and two in the anal. The scales are small, the upper surface of the head is naked, the preorbital as well as the preopercular bone is serrated, and there are seven branchiostegal rays and more than twenty-four vertebræ. As in most of the members of the family the mouth is capable of a certain degree of protrusion. The common perch, which seldom exceeds five pounds in weight, is distributed over the rivers of Europe (except Spain) and Northern Asia as far east as Lake Baikal; two others being known, namely, *P. flavescens* from the Eastern United States and *P. schrenki* from Turkestan. Generally preferring still waters, and occasionally descending into estuaries, the perch is one of the most voracious of fishes, feeding indiscriminately upon worms, insects, and small fishes. The spawning season in England is at the end of April or May, when the female deposits her eggs in net-shaped or elongated bands on the leaves of aquatic plants. The eggs are very numerous, upward of two hundred and eighty thousand having been taken from a fish of one-half pound in weight. Fossil remains of the genus occur in the Miocene rocks of Œningen, in Baden, and those of the extinct *Paraperca* in the upper Eocene of Provence.

Pike Perches The pike perches, of which the common European representative (*Lucioperca sandra*) is shown in the upper figure of the illustration on p. 2702, are inhabitants of many of the lakes and rivers of Europe, Western Asia, and Eastern North America, and take their name from their somewhat elongated and pike-like form. From the true perches they differ by the presence of more or less enlarged tusks in the marginal series of teeth, and by the wider interval between the pelvic fins. The two dorsal fins are rather low, the first having from twelve to fourteen spines, and the scales are small. The common species, which is confined to Eastern Europe, where it is much esteemed as a food fish, grows to a length of three or four feet, and attains a weight of from twenty-five to thirty pounds. Its extreme voracity and destructiveness to other fish render it an undesirable inhabitant of preserved waters.

Danubian Perches The two small and rather elongated perches represented in the upper part of the illustration on p. 2705, the larger of which is known as *Aspro zingel* and the smaller as *A. vulgaris*, may be taken as representatives of a subgroup distinguished from the foregoing forms and their allies

by the body being cylindrical or somewhat depressed; while from two allied genera they are distinguished by the maxilla or main upper jawbone being covered by the preorbital bone, and by the premaxilla being free only at the side. The body is elongate and nearly cylindrical in form, and the mouth is situated on the lower surface of the thick and somewhat projecting muzzle. All the teeth of the jaws are of small and uniform size, and teeth are present on the vomer and palatine bones. The anal fin has but a single spine; although the margin of the propercular bone is serrated, that of the preorbital is smooth; and the scales are small. These fishes inhabit the Danube and certain other European rivers.



LARGER AND SMALLER DANUBIAN PERCHES, AND RUFFE
(One-third natural size.)

Ruffes

Under this name, which belongs properly only to the British form, may be included a few small perches, of which the typical representative (*Acerina cernua*) is shown in the lower figure of the above illustration. From the other members of the family this and the allied genus *Percarina* differ by the

large size of the slime cavities on the sides and top of the head; the ruffes being specially distinguished by the dorsal fin being undivided, and also by the maxilla being covered by the preorbital bone. The fishes of this genus have the body somewhat low, and the scales somewhat small; the continuous single dorsal fin carrying from thirteen to twenty-nine spines, and there being two spines in the anal fin. There are no tusks among the small teeth of the jaws, and the tongue and palatine bones are devoid of teeth, although these are present on the vomer. The genus is confined to the cooler portions of the Northern Hemisphere, the common species ranging from Britain through Central Europe to Siberia. The "pope," as the ruffe is frequently called in England, is common in most of the rivers and canals of that country, generally preferring slow, shaded streams, with a gravelly bottom, and closely resembling the perch in its mode of life.

Family Centrarchidæ

Here may be mentioned a small family, with ten genera of perch-like fishes, distinguished from the *Percidæ* and the following family by the mode of attachment of the ribs, which, with the exception of the last, or last two or four, are inserted on the bodies of the vertebræ behind the transverse process, instead of the process itself; all the vertebræ in front of the tail, save the first two or three, having such processes. Externally, these fishes differ from the perches in the presence of at least three spines in the anal fin. The family is typified by the North-American genus *Centrachus*, of which there is but a single species. All are carnivorous fresh-water fishes, sometimes entering estuaries, and many are in the habit of building nests for the protection of their young.

Bass and Sea Perches — Family *SERRANIDÆ*

Although usually included in the *Percidæ*, with which they agree in the structure and relations of the vertebræ and ribs, the sea perches and their allies are regarded by Mr. Boulenger as representing a family by themselves, on account of the circumstance that the second suborbital bone develops an internal plate for the support of the eye. The number of spines in the anal fin is variable, and in one genus (*Centrogenys*) the lower pharyngeal bones are united. The family is a very extensive one, and may be divided into several subfamily groups.

South-American Perch and Bass

Together with the sea perches, the bass represent a subfamily (*Serraninæ*) presenting the following characteristics: The upper jaw-bone or maxilla is exposed, its upper border not being entirely concealed by the overlapping preorbital; the scales are not shed; there is no scaly process at the bases of the pelvic fins; the anal fin has three spines; the gill membrane is free behind, and the false gills are well developed. In distribution the subfamily is cosmopolitan, and while most of the forms are marine, a few inhabit fresh water. Among the latter may be mentioned the South-American perch (*Percichthys*) of Chili, Western Argentina, and Patagonia, which, in common with five other genera, has a divided dorsal fin. From an ordinary perch these fish may be distinguished by the scaly upper surface of the head, and the presence of

nine or ten spines in the first dorsal, and three in the anal fin. To this section of the subfamily also belong the bass (*Morone*), which are partly marine and partly fresh-water fishes, easily distinguished from the true perch by having only nine spines in the dorsal fin, while there are usually three in the anal. There are also teeth on the tongue, and while the preopercular bone is serrated, with denticulations on its lower border, the front border of the preorbital bone is entire. The



COMMON BASS, SEA PERCH, AND STONE BASS.
(One-sixth natural size.)

scales are rather small and extend all over the head. Of the three European and Atlantic species, which are almost entirely marine, the best known is the common bass (*M. labrax*), represented in the upper figure of the accompanying illustration, and characterized by its extreme voracity and fierceness. Elsewhere, the genus is represented by fresh-water species from the rivers of the United States and Canada. Fossil species occur in the middle Eocene of Italy. Generally not exceeding a foot or

eighteen inches in length, the common species may grow to three feet; but its flesh is then much less delicate than that of ordinary specimens. Bass frequent the coast in shoals, spawning in summer generally near the mouths of rivers, up which they not unfrequently ascend for considerable distances.

Sea Perch

In the other genera of the subfamily the dorsal fin is undivided, although it may be deeply notched; the number of its spines being generally nine or eleven, although there may be either eight, ten, or twelve. Under the common title of sea perches may be included the members of several allied genera, such as *Centropristes* and *Anthias*, although the name is often restricted to those of the typical genus *Serranus*, one of which (*S. scriba*) is represented in the middle figure of the preceding illustration. In the sea perches the body is oblong or compressed, and covered with small ctenoid or cycloid scales; there are large tusks among the villiform teeth of the jaws; and teeth are also present on the palatines and vomers, although absent from the tongue. The preopercular bone is serrated behind and at the angle, but not inferiorly; and the tail fin may be either rounded, squared, or emarginate. The sea perches of the genus *Serranus*, of which there are an enormous number of species, range through the seas of all the tropical and temperate regions, occasionally ascending tidal rivers for short distances in pursuit of prey, but being otherwise strictly marine. Many of the species vary considerably, both in color and in the form of their fins, with age, so that specific distinctions are difficult to establish. Extinct species of this genus, as well as others belonging to *Lates*, occur in the middle Eocene deposits of Italy.

Stone Bass

The fish represented in the lower figure of the preceding illustration, and commonly known as the stone bass (*Polyprion cernuum*), is one of two species constituting a genus distinguished from the last by the absence of large tusks in the jaws, and the presence of teeth on the tongue; the single dorsal fin having eleven or twelve spines, and the anal three. The preopercular bone is denticulated, and there is a strongly-marked rough longitudinal ridge on the opercular. The common species is abundant on the European coasts, while the second is from the seas of Juan Fernandez. Both attain a very large size, ranging in weight to eighty pounds or more, their flesh being of excellent quality. The European stone bass frequents the neighborhood of floating wood, probably for the purpose of feeding on the creatures to be met with around such objects.

Oriental and African Perches

The two species of the genus *Lates*, one of which (*L. niloticus*) inhabits the mouth of the Nile, while the second (*L. calcarifer*) ranges from the shores of Baluchistan through the Indo-Malayan seas to China and Australia, may be taken as representatives of another subfamily (*Centropominæ*), with three genera; this subfamily differing from the last by the extension of the lateral line on to the tail fin, the presence of a scaly process at the bases of the pelvic fins, and the small size or absence of the false gills. Having no teeth on the tongue, and a divided dorsal fin, these fish may be distinguished externally from the true perches by the presence of seven or eight dorsal and three anal spines. Both the preopercular and the preorbital bones are serrated, and the latter denticulated at the angle; the finely pectinated scales being of moderate size. The Indian perch, which may grow to a length of five feet, is the only Oriental



GROUP OF SCALY-FINNED FISHES.

1. *Chætodon setifer;* 2. *C. fasciatus;* 3. *C. trifasciatus;* 4. *Heniochus macrolepidotus;* 5. *Holacanthus diacanthus;* 6. H. *imperator.*

member of the family which commonly ascends rivers to any distance. When taken in the larger rivers its flesh is excellent for the table, great quantities being sold in the Calcutta market, where it is commonly known by the name of cockup. The allied genus *Psammoperca* is represented by two species, one ranging from Australia to China, while the other is exclusively Australian. There are many other generic representatives of this extensive family, which are far too numerous to mention, no less than twenty-seven occurring within the limits of British India. Among these the Indian genus *Pristipoma*, which is referred by some writers to a separate family, is represented by extinct species in the middle Eocene of Italy; and it may be mentioned here that the earliest known forms of the family are the extinct genera *Podocys* and *Acanus* from the lower Eocene of Switzerland.

The Scaly-finned Fishes — Family *Chætodontidæ*

Nearly allied to the perches, the beautiful tropical fishes, designated scaly-finned fishes, are so named on account of the characteristic feature of the median fins being more or less thickly covered with small scales. In addition to this distinctive feature, these fishes are characterized by the deep and compressed form of the body, on which the scales are either ctenoid or entire, and the continuous lateral line, which stops short of the tail fin. The mouth, which is generally small, is placed at the extremity of the muzzle, and has a distinct lateral cleft, and the eyes are on the sides of the head. The small teeth are arranged in bands, and there are neither tusks nor incisors. The soft portion of the single dorsal fin is rather longer than the spinous; the anal has three or four spines; the lower rays of the pectorals are branched; the pelvic pair are thoracic in position, with one spine and five soft rays, and the scaling of the median fins causes them to pass imperceptibly into the body. The great majority of these curious and beautiful fishes are inhabitants of tropical seas, and are very generally found in the neighborhood of coral reefs; but some ascend estuaries and tidal rivers, although but a comparatively-short distance. All are carnivorous, and of relatively-small size, while they are but seldom used for food. The three genera of which examples are represented in our illustration are those in which the zebra-like coloration attains its most marked and striking development; and for the beauty and singularity of their adornment these fishes are almost unequaled. Out of a large number of existing genera it is to these that our attention will be chiefly directed, and it may be remarked that the whole of them are met with in the Indian seas. Extinct species of zebra fish belonging to existing genera are found in the middle Eocene of Italy, among these being the Indian and Australian genus *Toxotes*. An extinct genus has been recorded from the Cretaceous of Westphalia.

Chætodon

The typical genus *Chætodon* belongs to a group of genera in which there are no teeth on the vomers or palatine bone, while the spines of the dorsal fin are not separated from the soft rays by a hollow or notch, and there is no spine to the preopercular bone; the genus in question being particularly distinguished by the short or moderately-long muzzle, and the approximately uniform

length of the spines of the dorsal fin. These fishes are common in the tropical regions of the Atlantic and Indo-Pacific oceans, where they are represented by some seventy species. Nearly all are ornamented with bands or spots; a dark or two-colored band passing through the eye and then inclining backward, being very characteristic. Of the species represented, *C. setifer*, ranging from the Red Sea to Polynesia, is readily recognized by the elongation of the fifth ray of the dorsal fin, behind the base of which is a large dark spot with a light rim; *C. trifasciatus*, which also has a similar range, but reaches the coasts of India, is marked by numerous fine longitudinal stripes on the body and several dark bands across the head. On the other hand in *C. fasciatus* of the Indian and Malayan seas, the body stripes are oblique, and there is a single dark band across the head.

Chelmon

Especial interest attaches to this genus, which contains but few species, and differs from the last by the elongation of the muzzle into a tube-like form, on account of the habits of one of its two Indian species (*Chelmon rostratus*). Of this fish, which has four dark bands on the head and body, and an eye spot on the soft dorsal fin, J. A. Schlosser wrote many years ago that it frequented the shores and sides of the sea and rivers in search of food, and that when it detected an insect perched on a plant it swam to within a distance of from four to six feet, and then with surprising dexterity ejected out of its tubular mouth a single drop of water, which never failed to strike the object aimed at into the water, where it was immediately seized by the fish. Some of these fish kept in tubs of water were seen to exercise their shooting powers even under these somewhat unfavorable circumstances. Somewhat later a Mr. Mitchell observed the same action in some of these fish kept in a pond near Batavia about the year 1828. Curiously enough, in spite of these circumstantial statements, this capacity for ejecting water was transferred to a short-snouted member of the present family, which received its name of *Toxotes* from this presumed power. Bleeker states, however, that when in Batavia he never witnessed this act, which is one the mouths of these fishes would appear quite incapable of performing.

Heniochus

The fish (*Heniochus macrolepidotus*) numbered 4 in the illustration on p. 2709, is a common Indo-Pacific member of a genus differing from *Chætodon* by the more or less marked elongation of the fourth spine of the dorsal fin, which in the figured species assumes the form of a whiplash. Broad dark bands across the body are very characteristic of the genus, and in the young the head is armed with numerous horn-like processes, where are permanently retained in a species named *H. varius*.

Holacanthus

The two large fishes shown in the illustration, swimming toward the left, belong to a genus distinguished from all the foregoing by the presence of a large spine on the hinder edge of the preopercular bone; the dorsal fin having from twelve to fifteen spines. The genus includes some forty species, with the same range as the typical representative of the family. The splendidly-colored emperor fish (*H. imperator*), shown on the right side of the illustration, ranges from the east coast of Africa to the Indian and Malayan seas, and has the ground color of the body a deep blue, upon which are some thirty longitudinal golden-yellow stripes. The eye stripe and a patch above the pectoral fin are black edged

with yellow, and the tail fin is uniformly yellow. This species, which attains a length of fifteen inches, is extensively used in India for food. Beautiful as it is, it is exceeded by the Indo-Malayan zebra fish (*H. diacanthus*). In this species the general color is yellowish, with from eight to twelve vertical brown-edged blue bands; the caudal fin is yellow, and the anal marked with bluish lines running parallel to its margin. The genus *Scatophagus* may be given as an example of a group in which the spinous portion of the dorsal fin is devoid of scales and separated by a deep notch from the soft part, so that there are practically two dorsals. The above-mentioned *Toxotes*, on the other hand, constitutes a group by itself, in which there are teeth on the palatines and vomers, and the body is oblong and much less deep than in the typical forms, with the undivided and five-spined dorsal fin situated in its hinder half. It is represented by three species, ranging from the Red Sea to the seas and estuaries of India, Malayana, and Polynesia.

The Red Mullets—Family *Mullidæ*

Two long erectile barbels dependent from the lower jaw serve at once to distinguish the red mullets from all the preceding families, with which they agree in the characteristics already mentioned. In these well-known fishes the body is rather low and somewhat compressed, with large thin scales, of which the edges may be very finely serrated. The lateral line is continuous, and the moderate-sized eyes are situated on the sides of the head. The terminal mouth has a rather short lateral cleft, and the teeth are very feeble. There are two short dorsal fins, placed at a considerable distance from one another; the spines of the first being weak, and the second being placed above the anal, which it resembles in form. The ventrals have one spine and five rays, and the pectorals are short. In place of the seven branchiostegal rays of the perches, the red mullets have but four. Represented by something like forty species, the red mullets, which range over the seas of Europe and the tropics, are typically represented by the genus *Mullus*, of which there appears to be but a single European species (*Mullus barbatus*). The tropical forms have, however, been split up into several genera, such as *Mulloides* and *Upeneus*, mainly distinguished from one another by the characteristics of their teeth. Although these mullets are essentially marine, young individuals, and more rarely adults, are not unfrequently taken in rivers. They are all highly esteemed for the table, and it is but seldom that they attain a weight of even two or three pounds. The ordinary European red mullet, which does not usually exceed six inches in length, is colored carmine red on the upper parts, the under parts being silvery white. On the other hand, the striped mullet, which, although designated a distinct species under the name of *M. surmuletus*, is regarded by Dr. Günther as probably the female of the former, has three or four yellow longitudinal stripes on the sides; and is also stated to differ slightly in the number of the fin rays. This kind is common on the Cornish coast, whereas the plain-colored form is but seldom met with in the British seas, although abundant in the Mediterranean. Mullets live chiefly on small crustaceans, frequent-

ing coasts where the bottom is more or less muddy. Occasionally they visit the British coasts in vast shoals, upward of five thousand having been taken during a single night, in August 1819, in Weymouth bay; while in May 1851 no less than ten thousand were captured at Yarmouth in the course of a week. Whereas by the ancient Romans these fish were known by the name of *mullus*, the Greeks termed them *trigle*. "A singular circumstance," writes Badham, "about this latter synonym is, that it not only obtains in modern Greece (where indeed, if anywhere, we might expect to find it), but has also entirely supplanted the old Latin word in Italy; so that no one now ever hears *Mugli! mugli!* hawked about the streets of Rome or Naples; but the constant cry is '*Trigle vive! trigle!*' The inordinate love for these same *trigle*, in the city and times of the Cæsars, would surpass belief; not



STRIPED RED MULLET.
(One-third natural size.)

only cash, but time too, was profusely lavished upon this one object; quite betimes, and long before office hours, the mullet millionaire was at the pond ere the stars were extinguished, feeding or caressing his fish. It took time, skill, and patience to teach creatures so obtuse to heed the voice that called, or the hand that fondled and fed them; but to warm such cold-blooded animals as these into a reciprocity of regard, was a work of yet greater difficulty. After much trouble and pains, the inhabtants of the pond would, however, at length learn to know and acknowledge their master; at his whistle flock emulously together, at his sight leap joyously into the air; and as he plunged his arm into the agitated basin, each individual of the serried shoal strove who should first present fins, and rub scales against the well-known fingers."

The Sea Breams—Family *Sparidæ*

The sixth family of the present section is especially characterized by the peculiarity of the dentition, the palate being generally devoid of teeth, while either cutting or conical incisor-like teeth are developed in the front of the jaws, or crushing molars on their sides; in some cases both these types being coexistent. In the sea breams, as these fish are commonly called, the oblong body is markedly compressed; and the investing scales are either but very slightly serrated, or smooth. The terminal mouth has a distinct lateral cleft; and the eyes, which are of medium size, are likewise lateral. The single dorsal fin is composed in about equal moieties of a spinous and a soft portion; the anal is three spined; as a rule the lower rays of the pectorals are branched; and the pelvics, which are ventral in position, are furnished with one spine and five rays. The number of branchiostegal rays varies from five to seven. Sea breams are coast fishes, distributed over all temperate and tropical seas, and sometimes entering brackish, and even fresh waters; they include a large number of genera, and are of sombre coloration and medium size; the flesh of the majority being used for food. In a fossil state the family is first known by the extinct *Pagellus* from the Chalk of the Lebanon; while they are numerous in Tertiary formations, where both the living and extinct genera are met with, the existing *Sargus* dating from the Miocene of the Continent.

Cantharus

The black sea bream (*Cantharus lineatus*) of the British seas may be cited as a well-known example of the typical genus of the first subfamily, in which the extremities of the jaws are furnished with broad, cutting, and occasionally lobate incisor-like teeth; while there are no vomerine or molariform teeth, and the lower rays of the pectoral fins are branched. Other well-known genera are *Box* and *Scatharus* from the Mediterranean and Eastern Atlantic, and *Crenidens* from the Indian seas. The black sea bream, which not unfrequently grows to a length of fifteen inches, is common on the British coasts, where it will take both vegetable and animal baits.

Haplodactylus

The second group is represented by *Haplodactylus* from the temperate South Pacific in which both jaws are furnished with flat and generally tricuspid teeth; vomerine teeth being present, but molars wanting; while the lower pectoral rays are simple. These fish are vegetable feeders.

Sargus

Better known than the last is the third group, containing only the single genus *Sargus*, with some twenty species from the Mediterranean, Atlantic, and Indian seas, among which the common sargo (*S. annularis*), represented in the upper figures of our illustration on p. 2715, is a familiar fish on the Continent. The essential features of the group are the single series of cutting teeth in the front of the jaws, the presence of several rows of molars on the sides of the same, the toothless palate, and the simple lower pectoral rays. The figured species is a uniformly-colored fish; but in the larger "sheep's-head" (*S. ovis*) from the Atlantic coasts of the United States, which attains a weight of fifteen pounds, and is highly esteemed for the table, the body and tail are marked by a number of broad vertical bands. The strong molars of these fish indicate that their food consists of

hard-shelled mollusks, crustaceans, or sea urchins. Known there as *dentice*, these fishes form part of the bill of fare on the tables of hotels in Southern Italy.

Giltheads

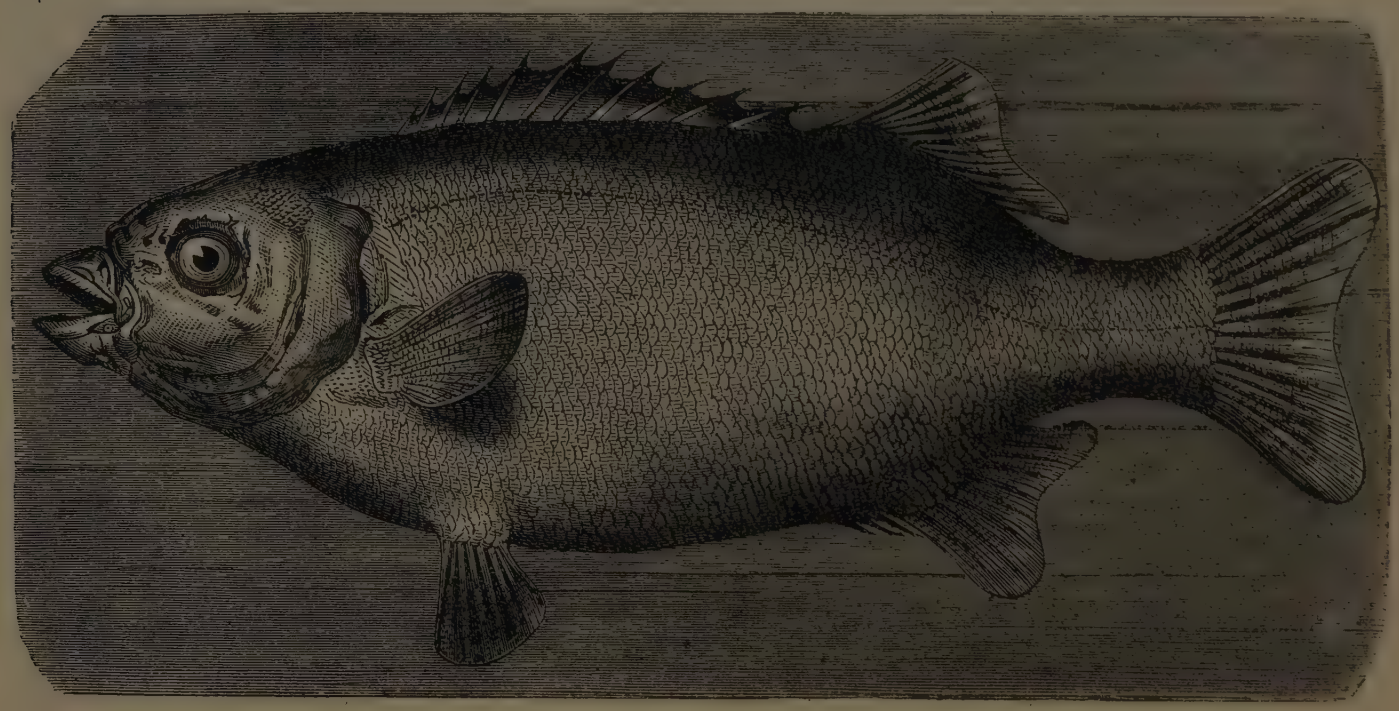
As our example of the fourth subfamily which contains several genera, among which *Pagrus* is the typical one, we select the giltheads (*Chrysophrys*), so called on account of the golden spots between the eyes of the Mediterranean *C. aurata*, a species which occasionally wanders to the British



SARGO AND GILTHEAD.
(One-third natural size.)

coasts, and is shown in the lower figure of our illustration. The group is characterized by the presence of conical teeth in the front of the jaws, and of molars on their sides, the palate being toothless; while the genus under consideration is distinguished by having scales on the cheeks, and at least three rows of upper molars. The Mediterranean gilthead, which ranges southward as far as the Cape, is a handsome fish, with a short and elevated head, the body deepest at the commencement

of the dorsal fin, the iris yellow, a semilunar golden spot between the eyes, and a violet patch on the gill cover. The back is silvery gray with a tinge of blue, and the under surface steely, with longitudinal golden bands on the sides. In length it seldom exceeds a foot. Fully adult examples show a perfect pavement of teeth on the jaws; and with these the fish crunches up mussels and other shell fish with such vigor that the noise thus made sometimes reveals its presence to fishermen. In order to obtain food, it is stated to stir up the sand of the sea bottom with its tail. The gilt eye was one of the fishes kept and fattened by the Romans in their vivaria, where it is said to have become extremely flat. Several species of the genus inhabit the seas and estuaries of India, one of which (*C. berda*) occasionally grows to thirty inches in length, and is much esteemed as food in Madras, where it is known as black-rock cod. Fossil teeth of a gilthead occur in the Red Crag of Suffolk, and the Miocene strata of Malta and the Canaries.



AUSTRALIAN KNIFE-JAWED FISH.
(One-third natural size.)

The Knife-jawed Fishes — Family *HOPLOGNATHIDÆ*

A single small genus of fishes (*Hoplognathus*) from the coasts of Australia, Japan, and Peru constitutes a separate family of the present section, characterized by the jawbones having a sharp cutting edge; such teeth as are present being confined to this region, where they are confluent with the bone, to form a more or less indistinct serration. The compressed and deep body is covered with very small ctenoid scales; while the sides have a continuous lateral line. The dorsal fin has its spinous portion rather longer than the soft, with the spines very strong; the anal, which has three spines, is similar to the soft dorsal; and the thoracic pelvics are furnished

with a single spine and five rays. The species figured on the opposite page is the Australian one (*H. conwayi*). Nothing seems to have been ascertained with regard to the life history of any member of the family.

The Thick-rayed Fishes — Family *Cirrhitidæ*

This small family, which, for want of a better English name, we designate as above, comprises several genera from the Indo-Pacific and Australasian seas, some members of which are of the first importance as food fishes in the British colonies. Closely allied to the next family, they differ therefrom (and thereby resemble the preceding groups) in the absence of a bony connection between the preopercular bone and the infraorbital ring of the skull; and they are specially distinguished by the thickened and undivided lower rays of the pectoral fin, which in some cases are elongated so as to aid in the movements, while in others they may perhaps serve as



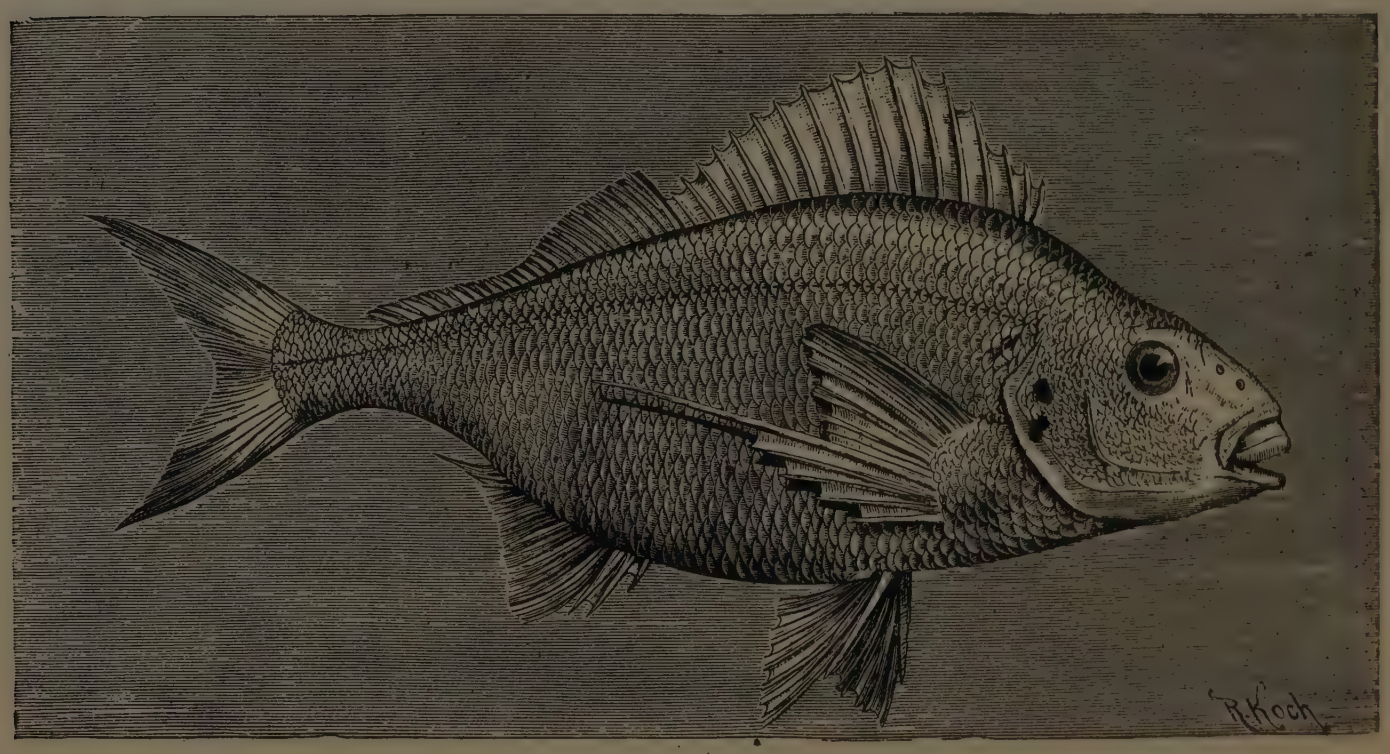
SPOTTED FIRM FIN.
(One-half natural size.)

additional organs of touch. In form, the body is oblong and compressed, with its investing scales of the cycloidal type; the mouth is terminal, with a lateral cleft; and the eyes are situated on the sides of the head. As a rule, the branchiostegal rays are six in number, although they may be reduced to five or three. The teeth are villiform or pointed, and in some cases there are tusks among the smaller ones. In the single dorsal fin the spinous and soft portions are of nearly equal extent; the anal fin, which is generally smaller than the soft dorsal, carries three spines; and the pelvics, which, although thoracic in position, are situated at a considerable distance from the root of the pectorals, have one spine and five rays. These fishes are inhabitants of all tropical seas and the temperate zone of the South Pacific. They

may be divided into two groups, according to the presence or absence of teeth on the vomers; the first group including the small prettily-colored fishes known as *Cirrhites*, *Chorinemus*, etc., of which the former are characteristic of the Indian and Pacific Oceans, while the latter is confined to the Australasian seas.

Cirrhitichthys

Of the group with teeth on the vomers, we illustrate on p. 2717 a species (*Cirrhitichthys marmoratus*) of a genus differing from the typical one by the presence of teeth on the palatine bones, and by the spiny opercular bone; the preopercular being serrated in both. These fish have six branchiostegal rays, tusks in the jaws, and ten spines in the dorsal fin. Five to seven of the lower pectoral rays are unbranched, the scales are of moderate size, and there is no air bladder. The spotted firm fin, which ranges from the Red sea, through the Indian and Malayan seas to the Sandwich Islands, is one of those in which there is no



AUSTRALIAN LONG FIN.
(One-half natural size.)

elongation of a ray of the pectoral fins; while it is specially characterized by the spotted coloration, the body and median fins showing brown spots, and a row of darker spots occupying the base of the dorsal.

Chilodactylus

In the group with toothless vomers, one of the most notable genera is that of the long fins (*Chilodactylus*), so named on account of the elongation of one of the rays of the pectoral fins, which projects to a greater or less degree beyond the rest. A considerable number of species have been described, most of which are inhabitants of the temperate region of the South Pacific, although some are found round the coasts of Japan and China. The species here figured (*C. macropterus*) is an Australian one; and both in Australia and at the Cape these fishes form a valuable food supply, since they attain a weight of from five to twenty-five pounds, and are easily captured. An allied genus

(*Latris*), distinguished by the absence of any elongation of the pectoral rays and the deeply-notched dorsal, is well known in Tasmania and New Zealand in the person of the trumpeter fish (*L. necatia*), which claims the first place among the fish products of those colonies, ranging in weight from thirty to sixty pounds, and being at the same time most excellently flavored.

The Scorpænoids — Family *SCORPÆNIDÆ*

With this family we come to a group easily distinguished from all the preceding representatives of this section by the articulation of the preopercular bone with the orbit by means of a projecting process from the infraorbital ring. Some of the other bones of the head are also armed, and the dentition is but feebly developed. These fishes, which are represented by a large number of genera, are found in most seas, and are all carnivorous in their habits. Dr. Günther writes that "some resemble the sea perches in their form and habits, as *Sebastes*, *Scorpæna*, etc., while others live at the bottom of the sea, and possess in various degrees of development those skinny appendages resembling the fronds of sea weeds, by which they either attract other fishes, or by which they are enabled more effectually to hide themselves. Species provided with these appendages have generally a coloration resembling that of their surroundings, and varying with the change of locality. Some of the genera live at a considerable depth, but apparently not beyond three hundred fathoms. Nearly all are distinguished by a powerful armature, either of the head, or fin spines, or both; and in some the spines have been developed into poison organs." The group is scarcely known in a fossil state, although remains of a species of the typical genus occur in the Eocene of Algeria.

The family is divided into two sections, according as to whether there are distinct scales on the body, or whether these are rudimentary or wanting. In the former are included *Sebastes* and the typical *Scorpæna*. Most curious of all are the members of the tropical Indo-Pacific genus *Pterŏis*, in which the spines of the dorsal and the rays of the pectoral fins are more or less produced,—so much so, indeed, that in the case of one species at least, *P. volitans*, it was formerly thought that they indicated the possession of flying powers in their owner. The fins and body of this extraordinary-looking fish are most beautifully marked with alternating light and dark transverse bands. Among the genera with small or rudimental scales we have only space to mention the Oriental *Pelor* and *Choridactylus*, each represented only by a single species of four or five inches in length; and both of which are remarkable for the extraordinary development of the appendages mentioned above, some of these occurring on the fins, and others on the head and lower lip. The representative of the second genus is very common at Madras. It may be added that this family includes the smallest members of the suborder, which belong to the genus *Micropus*—a name probably belonging to the swifts. These fish scarcely exceed an inch and a half in length, and frequent the coral reefs of the Pacific.

Allied Families

Of the three remaining and comparatively unimportant families, included in the perch-like section of the spiny-finned fishes, it is only possible to make very brief mention. The first of these, the *Nandidæ*, differs from all the foregoing by the incompleteness or absence of the lateral line; the dentition, although feebly developed, being more or less complete, and the preopercular bone having no connection with the orbit. The oblong and oval body is scaled; the number of spines in the dorsal fin is nearly equal to that of the rays; the three-spined anal has its soft portion similar to the soft dorsal; and the thoracic pelvic fins have one spine and four or five rays. The small Oriental fresh-water fishes known as *Nandus*, *Badis*, etc., constitute a group of the family characterized by the presence of five rays in the pelvic fins, and the absence of false gills. They are common in all parts of India, some preferring ditches and inundated rice fields, while others frequent clear streams. All are carnivorous, and the largest does not



BLEEKER'S PLESIOPS.
(One-half natural size.)

exceed seven inches in length. The second group, as represented by *Plesiops* from the Indo-Pacific coral reefs, and *Trachinops* from the Australian seas, although also including only small forms, are, on the other hand, marine; and are characterized by having only four rays to the pelvic fins, and by the presence of false gills. In *Plesiops* the lower rays of the pelvic fins are elongated and split at the ends; the soft dorsal and anal fins being likewise of considerable length. The figured species (*P. bleekeri*), which attains a length of ten inches, is from the coral islands of the Southwest Pacific; it has the lateral line broken.

Polycentrus

The second family (*Polycentridæ*) is represented only by the genera *Polycentrus* and *Monocirrhus*, from the rivers on the Atlantic side of tropical America; our illustration showing a member of the former genus (*P. schomburgki*). These fishes are characterized by the absence of a lateral line, and the great number of spines in both the dorsal and anal fins. The thoracic pelvic fins

have one spine and five rays, and the teeth are feeble. These fishes are all of very small size, and are stated to feed exclusively upon insects.

Teuthis

The single generic representative of the *Teuthididæ*, of which a species (*Teuthis striolata*) is shown in the illustration on p. 2722, is characterized by the toothless palate, and the presence of a series of narrow serrated incisor teeth in the front of each jaw. The scales on the oblong and compressed body are very small, and there is a continuous lateral line. In the single dorsal fin the spinous considerably exceeds the soft portion in length; the anal has seven spines; and the thoracically-placed pelvic fins have an outer and inner spine, between which are three rays. These fishes have a large air bladder, forked at both extremities; and they also display several peculiarities in the structure of the skeleton; the abdomen being surrounded by a complete ring of bones, owing to the backward prolongation of certain elements of the pectoral arch, and the unusual development of the pelvis. A considerable number of species have been described from the Indo-Pacific, where their eastward range stops about the longitude of the Sandwich Islands. The largest of them is not more than fifteen inches in length, and all are vegetable feeders. In the figured species, which is from the New Hebrides, the general color is brownish red, marked with narrow vermiculated blue lines; the spines of the fins also bearing white spots.



SCHOMBURGK'S MANY SPINE.
(Two-thirds natural size).

The Berycoids or Slime Heads — Family *Berychidæ*

With the slime heads we come to a family distinguished from the whole of the preceding, and forming a group by itself characterized by the presence on the head of large mucous-bearing cavities, covered with a thin skin, and by the thoracically-situated pelvic fins having one spine and five rays (save in *Monocentris*, where the latter are reduced to two). The compressed body may be either oblong or deep in form, but is always short; and the scales, which are rarely wanting, are of a ctenoid type. Lateral in position, the eyes are almost always large in size; the lateral cleft of the mouth slopes obliquely upward; the teeth in the jaws are villiform; teeth are in most cases developed on the palatines; the bones of the gill cover are more or less fully armed; and there are nearly always eight branchiostegal rays, although these are sometimes reduced to four. There are no scales on the head, and false gills are present. The slime heads, which comprise a considerable number of both living

and extinct genera, are all marine fishes, with a practically cosmopolitan distribution; many of them living at great depths, and coming under the denomination of deep-sea fishes. They are also a geologically ancient group, represented by a large number of generic types, both existing and extinct in the Chalk and other Cretaceous deposits. The only existing forms that frequent the higher strata of the ocean belong to the genera *Holocentrum* and *Myripristis;* but even some species of the latter may descend as deep as one hundred and fifty fathoms. The typical genus *Beryx* has been taken from between three and four hundred fathoms; and from the small size of the eye the forms known as *Melamphaës* must, in Dr. Günther's opinion, in-

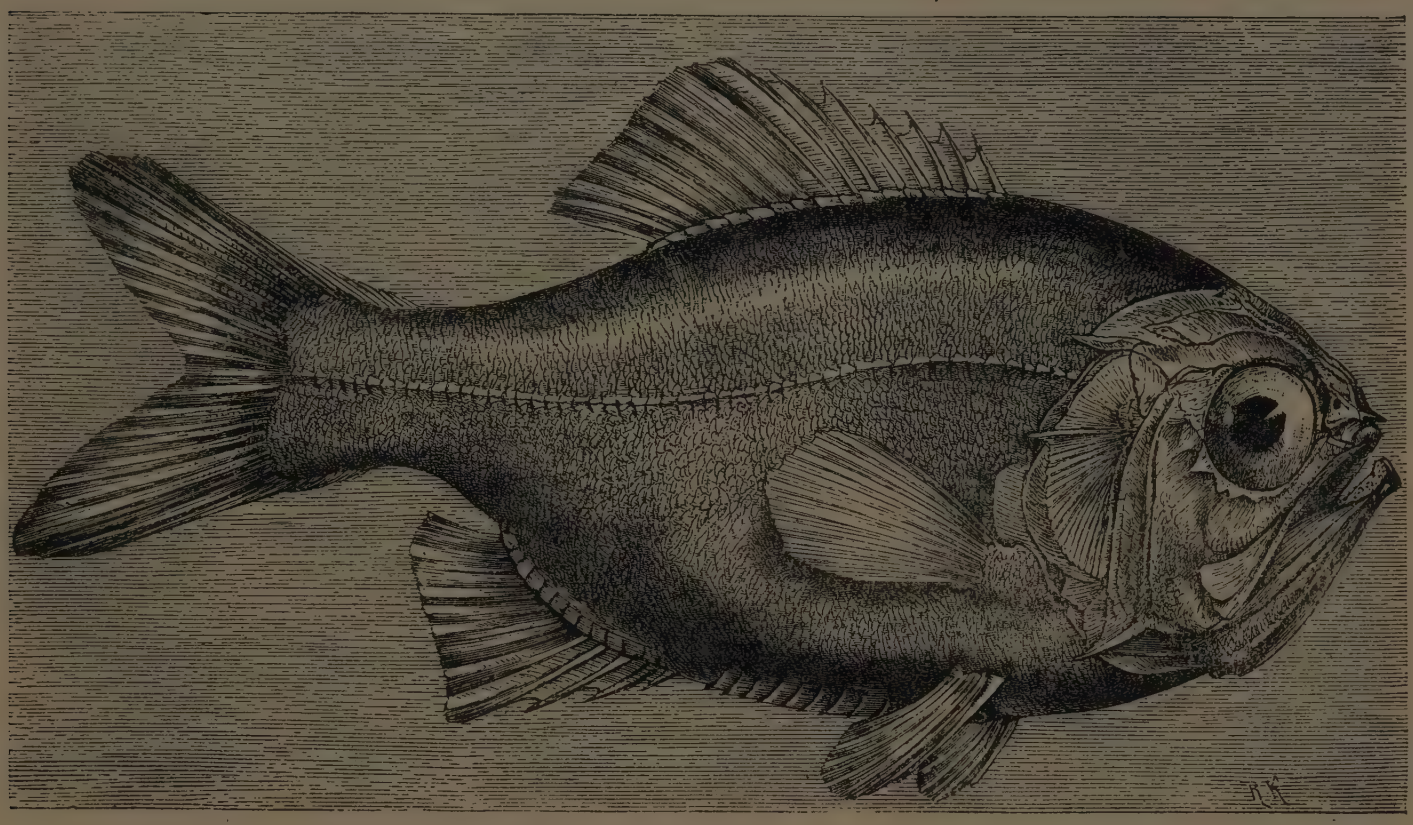


GROUP OF SPINE-FINNED FISHES.
Teuthis (upper figure); *Pempheris* (on the right); and *Polynemus* (on the left).
(One-fifth natural size.)

habit still lower levels. Another sign of their deep-water habits is afforded by the high development of the slime-secreting apparatus of these fishes.

Of the genera that space permits of our noticing, the most peculiar is *Monocentris*, represented by a single small and rare species from the seas of Japan and Mauritius, and distinguished by the absence of armatures on the gill cover, the large size of the scales, which are articulated so as to form a solid armor, and the reduction of the ventral fins to a single long spine and a few rudimental rays. The fish figured in our illustration (*Trachichthys trailli*) represents a genus, with a few species from New Zealand and Madeira, characterized by the short and

blunt muzzle, the prominent chin, the strong spine at the angle of the preopercular, the rather small scales, and the serration of the lower border of the body. The palatines and vomers carry villiform teeth; the single dorsal fin has from three to six spines, the anal six rays, and the tail is strongly forked. The allied *Anoplogaster* of the tropical Atlantic is devoid of scales. In both genera the eye is very large. The typical genus *Beryx*, which has likewise but a single dorsal, may be distinguished by the smooth abdomen, and the lack of a spine on the preopercular. At the present day this genus is known from the tropical Atlantic, Madeira, and the seas of Australia and Japan; while in a fossil state it is abundant in the Chalk. Two barbels at the throat serve to distinguish *Polymixia;* while in several of the



NEW ZEALAND TRACHICHTHYS.
(Two-fifths natural size.)

other genera, such as *Holocentrum*, the dorsal fin is double. Spread over all tropical seas, the latter genus is likewise one of those dating from the Cretaceous epoch.

Families *CURTIDÆ* and *POLYNEMIDÆ*

Each of these two unimportant families represents a group of equal rank with the perch-like division of the suborder; the first being characterized by having the single dorsal fin much shorter than the long and many-rayed anal. The compressed body (as shown in the figure of *Pempheris mangula*, on the right side of the illustration on page 2722) is oblong in form, deep in front, and sharply narrowing toward the tail. If developed at all, the spines of the short dorsal are few in num-

ber; the scales are small or medium in size, and both the jaws, palatines, and vomers bear villiform teeth. While the typical genus *Curtus* is confined to the Indian seas, *Pempheris* ranges over the Indian Ocean, the Malayan seas, and the tropical parts of the Pacific. The presence of a number of filaments, which may attain an enormous length, is the most distinctive feature of the second family, as shown in the example of the type genus (*Polynemus plebejus*), represented on the left side of the illustration last referred to; while a second characteristic is to be found in the two rather short dorsal fins, situated at a considerable distance from one another, and a third in the well-marked mucous-bearing canals on the head. The body is oblong and somewhat compressed, with smooth or slightly ciliated scales, and a continuous lateral line. The muzzle projects somewhat beyond the mouth, which is inferior in position, with a lateral cleft, and the large eyes are lateral. There are villiform teeth in the jaws and on the palate, and the pelvic fins are thoracic in position, with one spine and five rays. These fishes, which form three genera, include a number of species haunting the shores of tropical seas, and sometimes entering brackish or fresh water. Their filaments, which sometimes exceed twice the entire length of the head and body and can be moved independently of the pectoral fins, serve as feelers; and as these fish live in muddy water, and generally have their large eyes obscured by a film, the use or such accessory organs of touch is easily understood.

The Sciænoids — Family *SCIÆNIDÆ*

Of more general interest than the last is the family of Sciænoids, among which the umbrine of the Mediterranean and the widely distributed meagre are well-known examples. In this group the spinous dorsal is abbreviated at the expense of the more or less elongated soft dorsal, which also exceeds the anal fin in length; and although mucous canals are well developed on the head, there are no filaments near the pectoral fin. The somewhat elongated and compressed body is coated with ctenoid scales, and the uninterrupted lateral line sometimes continued onto the tail fin. The long mouth is at the extremity of the muzzle; the eye is medium and lateral; and in addition to bands of villiform teeth, the jaws may carry tusks, although they are never provided with incisors or molars, and the palate is devoid of teeth. The preopercular bone is smooth, and without any bony connection with the orbit; and the thoracic pelvic fins carry one spine and five rays. Frequently the air bladder is provided with a number of appendages. These fishes have a rather curious geographical distribution, being unknown in the Pacific and Red Sea, but widely spread in the Atlantic and Indian Oceans, and especially common round the shores of India, where many species enter estuaries and rivers. Some species have, indeed, taken completely to fresh water, and never by any chance descend to the sea. Nearly all are eaten as food, and the air bladders of many of the Indian forms are extensively used as a source of isinglass.

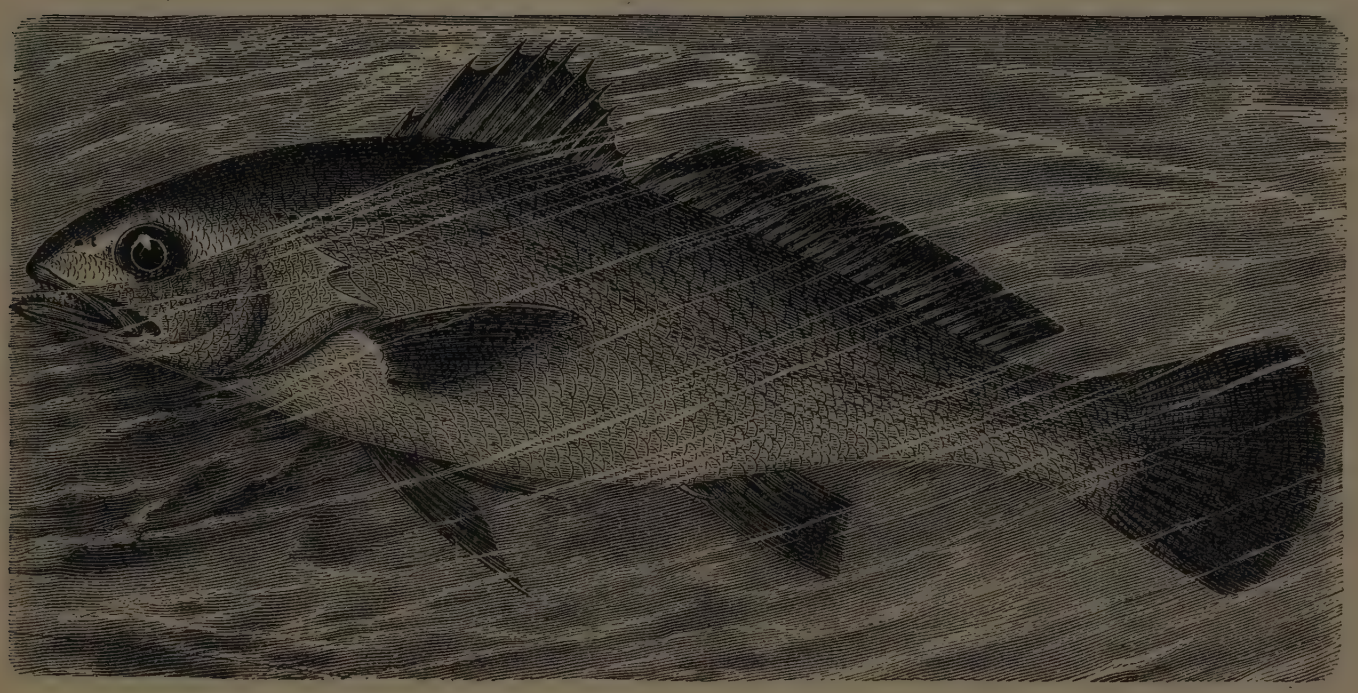
Drum

The North-American fish, rejoicing in the name of "drum" (*Pogonias chromis*), represents a genus characterized by the upper jaw of the convex muzzle overhanging the lower, the presence of numerous small barbels

on the chin, and the absence of tusks. Ten stout spines form the first dorsal fin, and there are two spines in the anal, the hindmost of which is very strong. The scales are of moderate size, and there are a number of large flattened molar-like teeth on the pharyngeal bones. In length the drum often exceeds four feet; while it may scale upward of one hundred pounds. In what manner the extraordinary drumming sounds uttered by this fish, in common with other members of the family, are produced, does not appear to be ascertained, although it has been suggested that they may be due to the clapping together of the upper and lower pharyngeal teeth.

Umbrines

The umbrine of the Mediterranean (*Umbrina cirrhosa*), whose range extends southward to the Cape, was a fish well known to the ancients, and is a member of a genus containing about a score of species distributed through the Mediterranean, Atlantic, and Indian Oceans. Having an overlapping upper



COMMON MEAGRE
(One-twelfth natural size.)

jaw, it differs from the last genus in the presence of but a single short barbel on the chin; while the first dorsal fin has ten flexible spines, and the anal either one or two. In size the typical species reaches about three feet.

Meagres

The third genus that we notice (*Sciæna*) differs from both the preceding in the absence of any barbels; the cleft of the mouth being oblique and deep, and the eyes situated rather wide apart. The genus includes a very large number of species, with a geographical range equal to that of the family; one of the best known being the typical meagre (*S. aquila*), ranging from the British coasts to those of the Cape and Australia. Although most of the species are smaller, this fish may attain a length of upward of six feet. Yarrell states that the flesh of the meagre "appears always to have been in great request with epicures; and, as on account of its large size it was always sold in pieces, the fishermen of

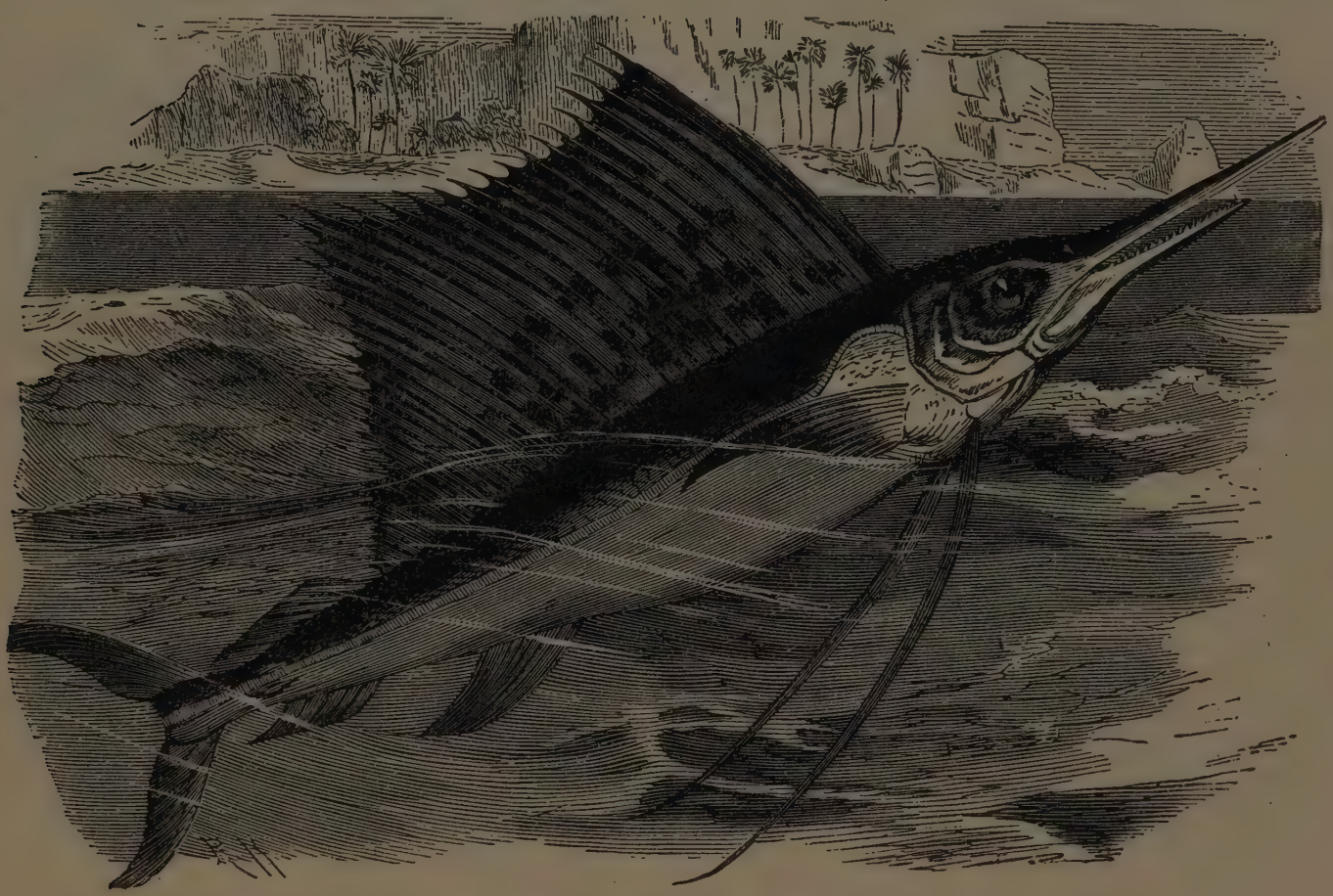
Rome were in the habit of presenting the head, which was considered the finest part as a sort of tribute to the three local magistrates who acted for the time as the conservators of the city.'' It is certain members of this genus that have taken to a fresh-water existence.

The Swordfishes — Family *XIPHIIDÆ*

With this small and well-defined family, all the members of which attain very large dimensions, we come to our first representatives of purely pelagic fishes. Sufficiently distinguished from all their allies by the production of the upper jaw into the long, wedge-shaped, sword-like weapon from which they take their name, the swordfishes are further characterized by the elongate and compressed body, the laterally-placed eyes, and the deep cleft of the mouth. Teeth are either absent or rudimentary, and scales are likewise wanting, or represented merely by small rudimental structures. The dorsal fin is either single or divided, but has no distinct spinous portion, and the pelvis, if present at all, takes the form of long, rod-like, thoracically-situated appendages. There are seven branchiostegal rays, and an air bladder is present. In the adult the sword is formed by the coalescence of the premaxillæ, vomer, and ethmoid, and is rough on the under surface from the presence of rudimental teeth. The swordfishes are divided into the genera *Xiphias* and *Histiophorus*, according to the absence or presence of pelvic fins; these appendages in the latter being in the form of from one to three rays. There is considerable variation in the height of the dorsal fin, which is frequently so lofty as to project some distance above the water when the fish is swimming near the surface, and even, it is said, to answer the purpose of a sail. In the young, this fin is much higher in proportion to the length of the body than it is in the adult. In very young examples of the typical genus the beak is comparatively long, there are conical prominences on the edge of the supraorbital, the occiput is devoid of a spine, and there are two short, tooth-like processes at the angle of the preopercular. In *Histiophorus*, on the other hand, the beak at a corresponding age is much shorter; the supraorbital edge is finely denticulated, or smooth, and there is a bony spine on each side of the occiput and at the angle of the preopercular. Although they are frequently not more than four to six feet in length, swordfishes may measure as much as from twelve to fifteen feet, and the sword itself may exceed a yard in length. The common European swordfish (*Xiphias gladius*), which is occasionally taken on the British coasts, ranges from the European seas to the opposite side of the Atlantic; while to the southward it occurs off the northern and western coasts of Africa. *Histiophorus*, on the other hand, seems to be confined to the Pacific and Indian Oceans, ranging eastward to Japan. Of the three Indian species, the spotted Indian swordfish (*H. gladius*) is distinguished by the dorsal fin being much higher than the body, and marked with dark blue spots on a lighter ground of the same color; the body being bluish gray above, and lighter beneath. On the other hand, in the black-finned swordfish (*H. immaculatus*) the general color of the body is dull gray, and the dorsal and anal fins are blackish. The third species (*H. brevirostris*) has

the dorsal fin lower than the depth of the body; the general color being gray, but the dorsal and pectoral fins tipped with black.

Mainly pelagic in their habits, swordfishes are among the most predaceous and savage of the monsters of the deep, transfixing their ordinary prey, which includes cod and tunny, with their formidable sword, and likewise attacking whales with the same weapon. In such conflicts, the swordfish, after making repeated stabs, generally comes out victorious, and the whale succumbs to his comparatively diminutive antagonist. Occasionally, however, one of these fishes appears to mistake a ship's bottom for a whale, and thereupon promptly charges it, sending the sword crashing through several inches of solid timber. In such cases it may happen that the swordfish cannot withdraw its weapon, which is then broken off short in the



SPOTTED INDIAN SWORDFISH.
(One-twentieth natural size.)

struggles of its owner to escape. One thing we should like to see cleared up by actual observation, and that is, in what manner a swordfish manages to remove from his weapon a cod, or other fish, which it has spitted. Instances are on record of these fish attacking and transfixing bathers; one such having occurred in the estuary of the Severn about the year 1830. Writing of one of the Pacific species, Colonel Pike observes that "this fish is a beautiful sight in the water. It has a habit of lying sunning itself on the surface when undisturbed, its dorsal fin is fully expanded and acting as a sail (and when needed it can propel itself at great speed); but it is only in the calmest weather it can be thus seen. It is frequently caught in deep water with hook and line, and when near the surface it is speared." When it feels the hook or spear, a swordfish takes tremendous leaps in the air, and if care

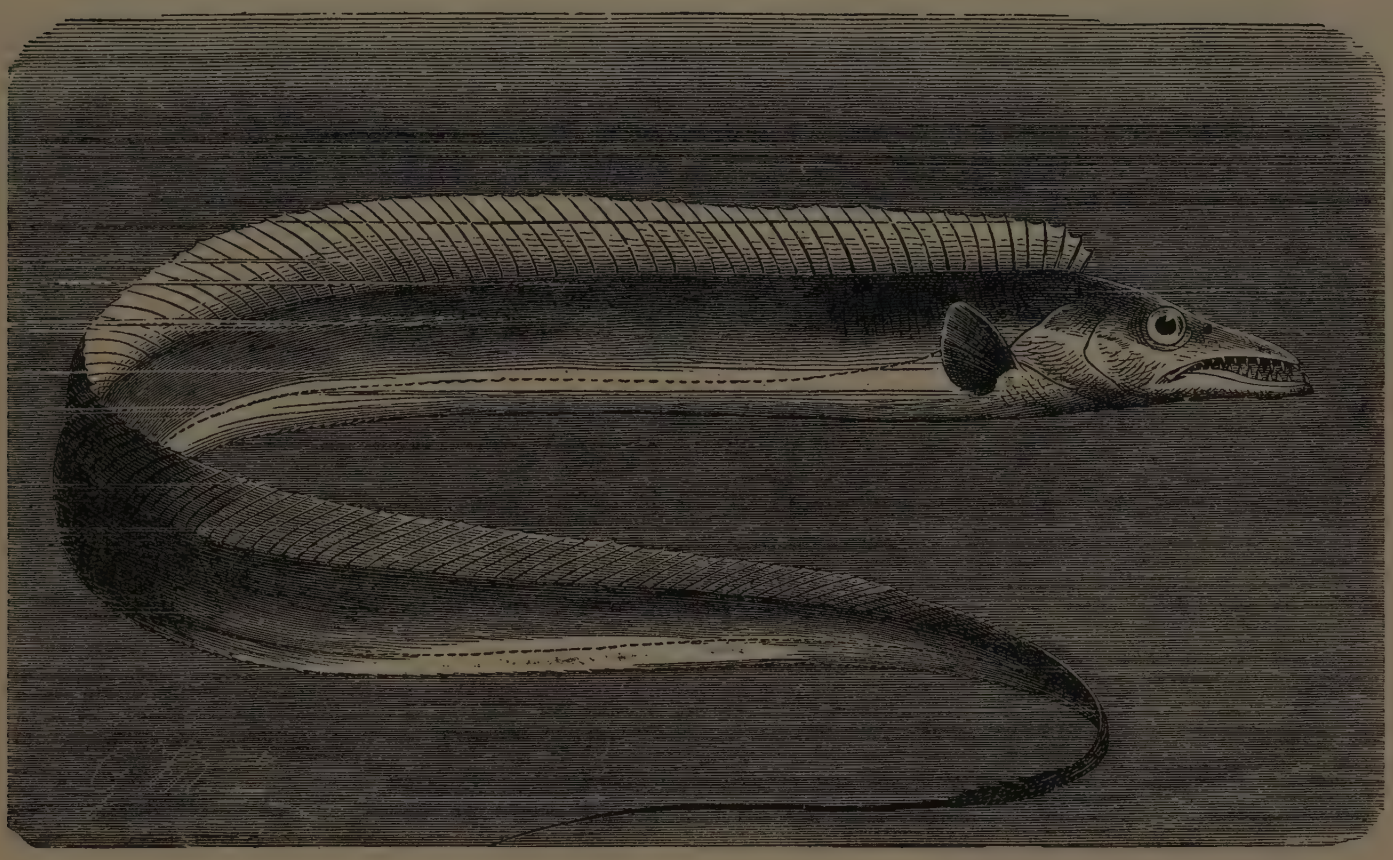
be not exercised, will jump into the boat of the fishermen. In the South Sea islands young swordfish are caught in strong nets, although no net will hold a fish of six feet in length. One of the most recent instances of a swordfish attacking a ship occurred in the year 1874, on the voyage between Bombay and Calcutta. On this subject Frank Buckland writes that there is in the Museum of the College of Surgeons a section of the bow of a South-Sea whaler, in which "is seen the end of the sword of a swordfish, measuring one foot in length and five inches in circumference. At one single blow the fish had lunged his sword through, and completely transfixed thirteen and one-half inches of solid timber. The sword had, of course, broken off in the hole, and thus prevented a dangerous leak in the ship. In the British Museum is a second specimen of a ship's side with the sword of a swordfish fixed in it, and which has penetrated no less than twenty-two inches into the timber. When His Majesty's ship *Leopard* was repairing, in 1795, after her return from the coast of Guinea, a sword of one of these fishes was found to have gone through the sheathing one inch, next through a three-inch plank, and beyond that four and one-half inches into the firm timber; and it was the opinion of the mechanics that it would require nine strokes of a twenty-five-pound hammer to drive a bolt of similar size and form to the same depth into the same hull; yet this was accomplished by a single thrust of the fish." In the Mediterranean countries, where these fishes are commonly taken in tunny nets, their flesh is exposed for sale in the markets. Geologically, the swordfishes appear to be a comparatively modern group, the earliest known representatives, which have been assigned to the existing genus *Histiophorus*, occurring in the London Clay.

The Scabbard Fishes and Hairtails — Family *Trichiuridæ*

Another group of equal rank with the perch-like section is formed by a family of fishes, characterized by the elongate and compressed or even band-like form of the body; the mouth having a wide cleft and several large conical teeth either in the jaws or on the palate. The dorsal and anal rays are long and many rayed, with the spinous nearly equal in length to the soft portion, finlets sometimes occurring behind the latter; the pelvic fins, if present, are thoracic in position; and the caudal is sometimes wanting, but, when developed, forked. In all cases the scales are either rudimental or wanting, but the air bladder is constant. These fishes are distributed over all tropical and subtropical seas; but while some are surface forms, never found at any great distance from the coasts, others descend to considerable depths in the open sea; all are carnivorous, and many very powerful. In India, writes Day, "these fishes are held in various estimation in different places. In Baluchistan, and where salt is cheap, no one will touch them; but along the coasts of India they are more esteemed, mostly because being thin or ribbon shaped they can be dried without salting. In a fossil state these fishes date from the lower Eocene of Switzerland and other parts of Europe, where they are represented by extinct genera; species of scabbard fish occur in the Sicilian Miocene, which has also yielded forms allied to the hairtails (*Trichiurichthys*), but with the body scaled.

Scabbard Fish

Among the better-known forms, the scabbard fish (*Lepidopus caudatus*) represents a genus characterized by the absence or rudimentary condition of the pelvic fins, the long single dorsal, and the distinct but small tail fin. Although it may attain a length of five or six feet, the attenuation of the body is so great that the whole weight does not exceed as many pounds. The fish has a very wide geographical distribution, ranging from the Mediterranean and warmer regions of the Atlantic to the Cape, and thence to New Zealand and Tasmania, while it occasionally wanders to the British coasts. This wide range may probably be taken as an indication that the scabbard fish is a comparatively deep-sea form. In New Zealand, where it is known as the frostfish, the scabbard fish is highly esteemed for its flesh, which is white, rich, firm, and tender, with an excellent



SCABBARD FISH.
(One-thirteenth natural size.)

flavor. On this account, says an anonymous writer, "the fish is eagerly sought after, and commands a high price, as the supply is irregular, and not equal to the demand. Not much is yet known of the manners and customs of the frostfish, but the little that has been made manifest is decidedly peculiar. It is a deep-water fish, and yet, strange to say, has never yet been taken by the net, the rod, or the line. Even the all-gathering trawl has hitherto failed to bring it to the surface of the deep. How then is its capture effected? To all appearance the frostfish is captured by the fishermen only when it commits suicide and immolates itself on the sandy beaches of the Pacific. The facts are, that on calm and frosty nights, during the autumn and winter months, numbers of frostfish come ashore alive through the surf on the beaches before referred to, and there wriggle on the firmer sands

above, to be devoured by the watchful sea birds, or picked up by the fortunate fisherman. No satisfactory reason has as yet been assigned for this rash act, although numerous theories have been propounded to account for it. One is that the hapless fish is pursued by a shark or other enemy, and prefers uncertain life on land to certain death at sea. Another and a more plausible theory is that the fish distends its air bladder to enable it to reach the surface for air or food, and that the keen frosty air there prevents it from compressing the bladder, and thus returning to its habitat under the waves. In this way the luckless fish gradually drifts into shallow water, and is dashed ashore by the surf, only to struggle onto dry land to meet its fate. As may be imagined, the capture of the frostfish has nothing specially sportsman-like about it. The long sandy beaches some twelve miles from Dunedin are the favorite resort of the frostfisher. The usual plan is to form a party of two or more, and camp out overnight at the foot of the cliffs which overhang the beach. Here a huge fire is lighted, and a tent pitched close at hand. The night, of course, must be clear and calm, as well as frosty, otherwise the long Pacific rollers make the surf too high for the successful capture of the game. The fishing itself is rather slow work. It consists merely in walking from end to end of the beach shortly before dawn (the untimely hour chosen by the fish for self-destruction), and keeping a sharp lookout in the surf for the silver streak which betokens the advent of the frostfish. When a fish is seen struggling in the waves or on the sand, all that remains to be done is to catch hold of it, and drag it up out of reach of the backwash (if it does not wriggle up by its own motion), and there dispatch it with a stick or knife."

Hairtails

These scaleless fishes (*Trichiurus*) take their name from the absence of a caudal fin, the body tapering posteriorly into a fine point. The single dorsal extends the whole length of the ribbon-like body; the pelvic fins are represented merely by a pair of scales, or are completely wanting; and the anal is rudimental, its spinous portion being reduced to a number of very small spines scarcely projecting above the skin. The jaws are provided with long tusks, and there are teeth on the palatine bones, although none on the vomer. Essentially tropical fishes, generally found in the vicinity of land, they appear to be sometimes carried by currents out to sea, which will probably account for the occasional appearance of the West-Indian *T. lepturus* on the British coasts. These fishes attain a length of from three to four feet; and one of the Indian species is described as extremely voracious, preying on crustaceans and various fishes, among which members of its own kind are included.

Barracudas

The local name for a New Zealand representative (*Thyrsites atun*) of another genus may be taken as the popular title of all its members. These fishes, in which the rather elongate body is covered with minute scales, are characterized by having from two to six finlets behind the dorsal and anal, and the presence of teeth on the palatines. Barracudas, which grow to as much as five feet, form important food supplies in the Cape, South Australia, New Zealand, and Chili; when the flesh has been dried or otherwise preserved, it is exported from New Zealand in quantities to Mauritius and Batavia. The genus is unknown in the Indian seas, where the family is represented by the hairtails.

Allied Extinct Forms

Two extinct genera, namely, *Palæorhynchus* from the Eocene of Switzerland and *Hemirhynchus* from the Oligocene of France, represent a separate family (*Palæorhynchidæ*), distinguished from the last by the production of the muzzle into a long beak, which may be either provided with small teeth or toothless. The dorsal fin occupies nearly the whole length of the compressed body, and the anal fin is also elongated, and extends nearly to the forked caudal.

The Surgeons — Family *ACRONURIDÆ*

With this family we come to a group of spiny-finned fishes, including some thirteen others, which present the following characteristics in common: The dorsal fins are either placed together or continuous, the spinous portion being, when fully developed, shorter than the soft part, while it may be modified into tentacles, detached spines, or an adhesive disc; and the anal is similar in characteristics to the soft dorsal, and in some instances both these fins are modified posteriorly into finlets. The pelvic fins, if developed, are always thoracic or jugular in position, and are never modified into a sucker; and there are no papillæ in the neighborhood of the vent. Nearly the whole of the members of the group are marine.

The first family is typified by a genus (*Acronurus*) the representatives of which are popularly known by the name of "surgeons," owing to the presence of a sharp lancet-like spine on each side of the tail in the adult. In addition to the presence of one or more such spines or bony plates, the family is further characterized by a single dorsal fin, with a very small number of spines. The body is compressed and oblong or deep in form, with a covering of minute scales; the moderate-sized eyes are lateral in position; the small mouth is furnished in front with a single series of more or less compressed upper and lower incisors, which may be either pointed or serrated; but the palate is toothless. The pelvic fins are thoracic in position, and the hinder extremity of the air bladder is forked. These fishes are inhabitants of all the tropical seas, and are most common in the neighborhood of coral reefs and islands, where some feed on the soft polyps of the coral, but others on various vegetable substances. In the true surgeons (*Acronurus*) there is an erectile spine situated in a groove on each side of the tail, and the pelvic fins are generally furnished with a single spine and five rays. In the young the body is scaleless, and the tail spines either very small or wanting. These fishes are represented by a large number of species, the largest of which does not exceed eighteen inches in length, and they are distributed over all tropical seas with the exception of the Eastern Pacific. In a fossil state the genus, like the next, occurs in the middle Eocene beds of Monte Bolca, in Italy. From the true surgeons the members of the genus *Naseus*, which range over the tropical Pacific and the Indian Ocean, are distinguished by having from one to three nonerectile spines on each side of the tail, and the presence of only three rays in the ventral fins; while in some forms the head is armed with a forwardly-directed bony horn or crest-like prominence.

The minute and rough scales make the skin like fine shagreen. A third genus (*Prionurus*) differs in having a series of keeled bony plates instead of spines on the sides of the tail. All the species of *Naseus* are said to be purely herbivorous. The true surgeons use their spines as formidable weapons of attack by erecting them and striking sideways with their tails.

The Horse Mackerels — Family *CARANGIDÆ*

Although the name horse mackerel properly applies only to a single British fish (*Caranx trachurus*), otherwise known as the scad, it may conveniently be made to do



COMMON MACKEREL AND HORSE MACKEREL.
(One-third natural size.)

duty for the whole of the members of the family to which that species pertains. Having the body more or less compressed, these fishes are specially distinguished by the teeth, when present, being villiform or conical. The spinous portion of the dorsal fin is sometimes rudimental; the hinder rays of both the dorsal and anal may be broken up into separate finlets, and when present, the pelvic fins are thoracic in position. In the skeleton there are ten trunk and fourteen tail vertebræ, although

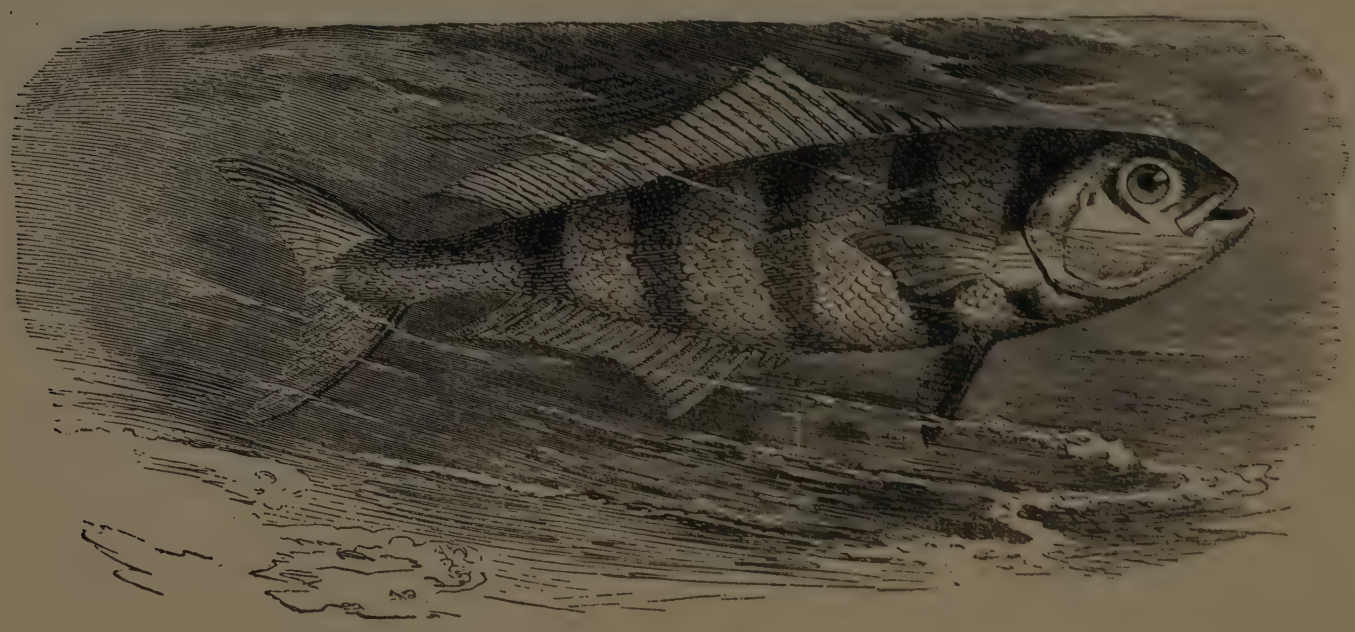
in one genus the number of the latter is increased to sixteen. The gill openings are wide, the eyes lateral, and there is no bony stay connecting the preopercular with the infraorbital ring. The scales, which are usually small, may be altogether wanting, and in many cases the lateral line is wholly or partially armed with shield-like overlapping plates. There is always an air bladder. In the young of some forms there is an armature of the head, which disappears in the adult. Carnivorous in their diet, the horse mackerels are distributed at the present day over all temperate and tropical seas; and were also abundant during the Tertiary period, and likewise represented by extinct genera in the antecedent Cretaceous epoch. Remains of these fishes are found in extraordinary profusion in the middle Eocene strata of Monte Bolca, one of the most remarkable types from that formation being the extinct *Semiophorus*, in which the dorsal fin is so elevated as to exceed the total length of the head and body, while the pectorals formed a pair of backwardly-directed tapering spines.

True Horse Mackerels

In the typical genus *Caranx* the body is generally more or less compressed, although sometimes almost cylindrical; the hard dorsal fin, which may be rudimentary, is continuous, with about eight weak spines; while in a few species the soft portion of both this and the anal is broken up into finlets. The scales are very small, and while in the British horse mackerel (*C. trachurus*), represented in the lower figure of our illustration, the lateral line is protected by bony plates throughout its entire extent, in many other species these plates are restricted to its hinder moiety. Several of these plates may be traversed by a keel terminating in a spine. The genus is represented by nearly a hundred species, some of which have teeth on the palate, while in others these are wanting. Ranging over almost all temperate and tropical seas, many of them swim out to considerable distances from the shore, and thus acquire a very large distributional area. The larger forms may measure fully a yard in length; and the flesh of all is edible. The genus is represented in the Monte Bolca Eocene. Horse mackerel sometimes make their appearance in enormous shoals on the British coasts and it is stated that on one occasion upward of ten thousand were taken in Cornwall. A correspondent of Yarrell wrote, that in the summer of 1834 vast shoals of these fish were seen on the Glamorganshire coast. "They were first observed in the evening, and the whole sea, as far as we could command it with the eye, seemed in a state of fermentation with their numbers. Those who stood on some projecting rock had only to dip their hands into the water, and with a sudden jerk, they might throw up three or four. The bathers felt them come against their bodies, and the sea, looked on from above, appeared one dark mass of fish. Every net was immediately put in requisition, and those which did not give way from the weight, were drawn on shore laden with spoil. One of the party who had a herring seine with a two-inch mesh was the most successful; every mesh held its fish, and formed a wall that swept on the beach all before it. The quantity is very inadequately expressed by numbers, they were caught by cart loads. As these shoals were passing us for a week, with their heads directed up channel, we had the opportunity of noticing that the feeding time was morning and evening. They were pursuing the fry of the herring, and I found their stomachs constantly full of them."

Pilot Fish

Another genus is represented by the pelagic pilot fish (*Naucrates ductor*), which takes it name from a supposed habit of guiding and protecting the sharks and ships which it accompanies. Having no plates on the lateral line, this fish is further characterized by the rounded under surface of the body, by the first dorsal fin being composed in the adult of detached spines, by the absence of finlets, and the presence of a keel on each side of the tail. When adult, the pilot fish measures about a foot in length. In color, it is bluish, with five or six dark vertical bands; the tail fin sometimes having the ends of its two lobes dark, as also a band across the middle third. Ranging over all temperate and tropical seas, pilot fish were regarded as sacred by the ancients, by whom they were known as *pompili;* the common belief being that when the ship neared land, the fish suddenly disappeared, and thus gave warning to the sailors of impending danger. Many legends have grown in later times as to how pilot fish will prevent sharks from taking a bait by swimming round them and enticing them away; but all these



PILOT FISH.

appear to be pure fictions, and perhaps the best account of the real habits of the fish is one by Dr. Meyen, from which the following summary is taken. It appears that the pilot fish constantly swims in front of the shark, sometimes coming close to its muzzle or front fins as it approaches a ship, and sometimes darting sidewise or forward for a short distance, and then returning to the side of the larger ship. In one instance, where a baited hook was thrown over the ship's side, the pilot fish rushed up, and after swimming close to the bait, returned to the shark, and by swimming and splashing round it appeared to be attracting its attention. Soon after the shark began to move, with the pilot fish in front, and was almost immediately hooked. Instead of the pilot fish taking care of the shark it would rather seem to frequent the company of the latter for the sake of the fragments of food and other substances to be found in its neighborhood; and it is doubtless for the same reason that these fishes follow ships. In summer, pilot fish will not unfrequently accompany vessels into the southern British harbors; but their purely pelagic habits are

indicated by the circumstance that their spawn and fry are found far out in the open sea. The young both of this fish and of some of the allied forms are so different in appearance from their parents that they have been described under distinct generic names.

Sea Bats

Both the preceding genera belong to a group of the family in which the spines of the anal fin are detached from its soft portion. As an example of a second group in which these two portions are connected by membrane, we may notice the so-called sea bats (*Platax*), remarkable for the great height and compression of the rhomboidal body, and the strong development of the dorsal and anal fins, which are often nearly similar in form and size. Indeed, except that they are symmetrical and have an eye on each side of the head, the sea bats look almost like flatfishes. They have the spinous portion of the single dorsal fin almost concealed, and with from three to seven spines; the anal has three spines; and the pelvic fins, which are sometimes greatly elongated, have a single spine and five rays. The scales are rather smaller or medium; the palate is toothless; and the jaws have a series of outer teeth somewhat larger than the small ones of the inner rows. These fish, of which there are but few species, appear to be confined to the Red Sea, Indian Ocean, and the Western Pacific, where they are abundant. Some of them attain a length of about twenty inches, and the body may be marked by a few broad vertical dark bands, the long lobes of the fins being black. In young specimens the rays of the median fins are proportionately much longer than in adults, thus giving the whole fish somewhat the appearance of a cheese cutter. Sea bats are found in a fossil state not only in the middle Eocene of Monte Bolca, but likewise in the Cretaceous rocks of England and the Lebanon, so that the genus is an old one. In the allied genus *Psettus*, from the coasts of Western Africa and the Indo-Pacific Ocean, the pectoral fins are rudimental.

The Dories — Family *Cyttidæ*

The deep form of the compressed body, the division of the dorsal fin into two distinct moieties, and the circumstance that the number of trunk vertebræ exceeds ten, and that of the tail fourteen, form the leading features by which the small family of the dories are distinguished from the other members of the group under consideration. The body may be invested either with small scales or bony plates, or may be devoid of both. The eyes are lateral, and the teeth conical and small. There is no connection between the preopercular and the orbit; the gill opening is wide, and the pectoral fins are thoracic in position. The John Dory (*Zeus faber*), which gives the name to the family, and is said to derive its own title from a corruption of a foreign equivalent of "gilded cock," represents a genus with few species, characterized by a series of bony plates at the base of the dorsal and anal fins, and another on the under surface; the anal having four spines. The eight or nine spines of the first dorsal fin, which is not much shorter than the second, are produced into long slender filaments; and there are but few or no scales. The genus

ranges over the Mediterranean, the eastern coasts of the temperate zones of the Atlantic, and the Australian and Japanese seas; while in a fossil state it occurs in the Miocene deposits of Sicily. An exceedingly ugly and ill-favored creature, with a huge protruding mouth, the common dory is olive brown tinged with yellow in color, showing blue and metallic reflections in certain lights. The sides bear a large black spot, surrounded by a white ring; a similar mark occurring in some of the other species. A somewhat migratory fish on the British coasts, the dory has been long esteemed by epicures, and it is stated that its flesh is better on the second than on the first day. Couch writes that "when the pilchards approach the shore, the dory is often taken in considerable numbers. In the autumn of 1829 more than sixty were hauled on shore at once in a net, some of them of large size, and yet the whole of them were sold for nine shillings. It continues common until the end of winter, after which it is more rare but never scarce. The form of the dory would seem to render it incapable of much activity; and it is sometimes seen floating along with the current rather than swimming; yet some circumstances favor the idea that it is able to make its way with considerable activity. It keeps pace with shoals of pilchards, so that some are usually inclosed in the seine with them; it also devours the common cuttle, a creature of vigilance and celerity; and I have seen a cuttle of a few inches long taken from the stomach of a dory that measured only four inches." In the allied genus *Cyttus*, represented by three species from Madeira, South Australia, and New Zealand, the body is covered with minute scales, there are no bony plates, the number of spines in the anal fin is two, and the pelvic fins comprise one spine and six or eight rays.

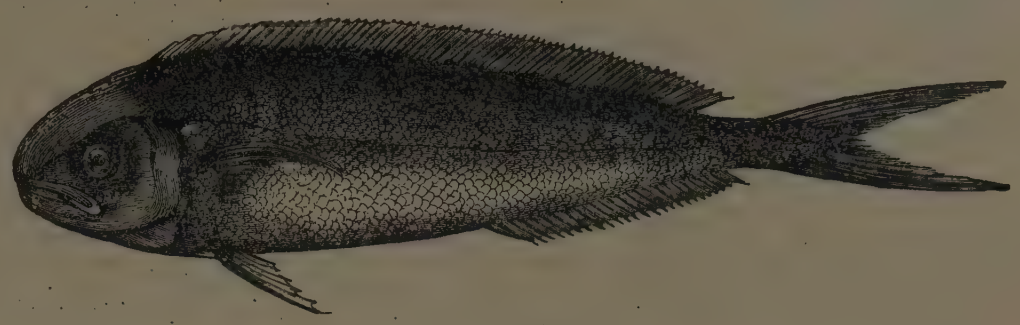
Stromateids and Coryphænas — Families *Stromateidæ* and *Coryphænidæ*

These two families are collectively distinguished from the preceding by the absence of any distinct spinous portion to the dorsal fin; the compressed body being either oblong, or very deep; and there being more than ten vertebræ in the trunk, and more than fourteen in the tail. In the first of the two the dentition is feeble, the palate being devoid of teeth; but there are horny barbed processes projecting into the œsophagus which take the place of oral teeth. The scales are very small, the eyes lateral, and the dorsal fin long. The typical genus *Stromateus*, which includes about half a score of species from most tropical and temperate seas, is characterized by the absence of pelvic fins in the adult; the dorsal and anal fins being long, with their points curving backward in several or the species, and the caudal deeply forked. In habits these fishes are partly pelagic.

Coryphænas

The second of the two families is represented typically by the well-known pelagic coryphænas (*Coryphæna*), popularly miscalled dolphins. As a family, the *Coryphænidæ* are readily distinguished from the *Stromateidæ* by the absence of tooth-like processes in the œsophagus. In the typical genus the body is somewhat elongated and compressed, the adults having an elevated crest on the top of the head; and the cleft of the mouth is wide. The single dorsal fin extends in a

nearly straight line from the back of the head almost to the deeply-forked caudal; the anal resembles the dorsal in having no distinct spinous portion; and the well-developed pelvic fins are thoracic in position, and can be received in a groove in the abdomen. Teeth are present in the jaws, as well as on the vomer, palatines, and tongue; the cycloid scales are small; and there is no air bladder. The coryphænas, of which there are some half-dozen species, are purely pelagic fishes, ranging over all temperate and tropical seas, and remarkable for the beauty of their fleeting colors. Dr. Günther observes that so "far as the colors are capable of description, those of the common species (*C. hippurus*), which is often seen in the Mediterranean, are silvery blue above, with markings of a deeper azure, and reflections of pure gold, the lower parts being lemon yellow, marked with pale blue. The pectoral fins are partly lead color, partly yellow; the anal is yellow, the iris of the eye golden. The iridescent colors change rapidly while the fish is dying, as in the mackerel. The form of the body, and especially of the head, changes considerably with age. Very young specimens, from one to six inches in length, are abundant in the open sea, and frequently obtained in the tow net. Their body is cylindrical, their head as broad as high, and the eye relatively very large, much longer that the snout. As the fish grows, the body is more compressed, and finally a high crest is developed on the head, and the anterior part of the dorsal fin attains a height equal to that of the body." This species ranges over all tropical seas, and attains a length of from five to six feet; although its flesh is unpalatable to Europeans, it is eaten by the natives of Madras. Powerful swimmers, and associating in large shoals, coryphænas are determined enemies to flying fish, pursuing them as they skim from wave to wave, and capturing them as they again fall into the water.



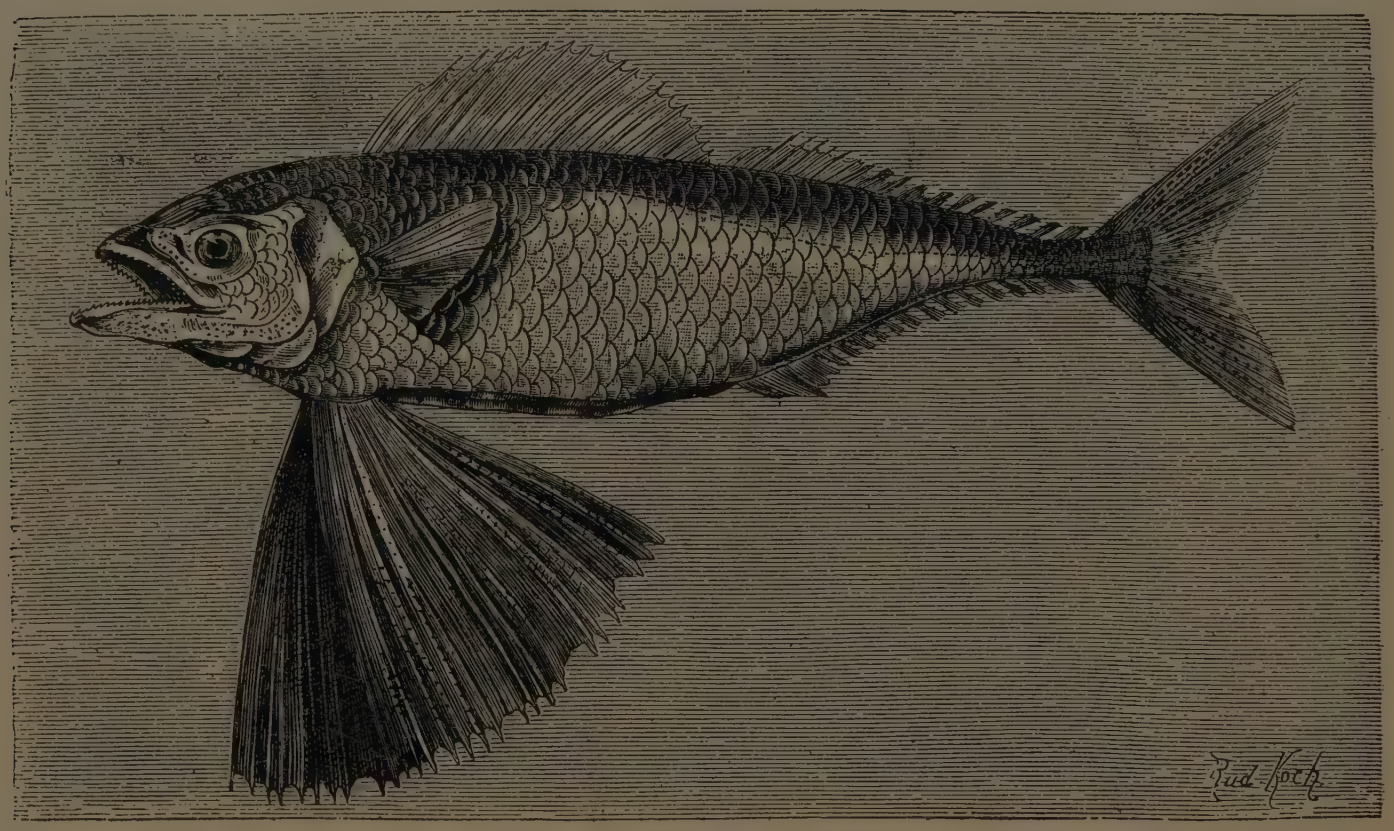
CORYPHÆNA.

Sunfish

As an example of genera in which the body is much compressed, short, and deep, we may select the sunfish (*Lampris luna*), of the North Atlantic and Mediterranean, the sole representative of its genus. The body is covered with very small deciduous scales, the mouth has a narrow cleft, and is devoid of teeth, the dorsal has its anterior portion elevated into a narrow point, and the pelvic fins are composed of numerous rays. This fish, which attains to the length of four feet, is remarkable for the beauty of its coloration, the body being bluish, with round silvery spots, and the fins brilliant scarlet. Its flesh is reported to be of good flavor. In the allied *Mene*, also represented by a single species (*M. maculata*), inhabiting the Indian and Malayan seas, and attaining a length of eight or nine inches, the jaws are toothed, the mouth is very protractile, and the first rays of the pelvic fins are greatly elongated. This genus is found in a fossil state in the middle Eocene of Monte Bolca; while in the London Clay we have the extinct *Goniognathus*.

Nomæids and Mackerels — Families *Nomæidæ and Scomberidæ*

Both these families agree in having two dorsal fins, and in the number of trunk vertebræ exceeding ten, and the caudal fourteen. In the first small and comparatively unimportant group there may be finlets behind the dorsal and anal fins; the dorsal has a distinct spinous portion, the caudal is forked, and the body covered with cycloid scales of moderate size. All these fishes are marine, and, in the young state at least, pelagic. Of the better-known genera, *Gastrochisma*, with a broad cleft to the mouth, finlets on the back and abdomen, and enormous pelvic fins, capable of being folded into a cleft in the body, and of which the position is thoracic, is known by a single New-Zealand species (*G. melampus*). On the other hand, *Nomæus*, with two species from the tropical Atlantic and Indian Oceans, lacks finlets, and has a narrow mouth cleft.



NEW ZEALAND GASTROCHISMA.

Mackerels

The second of the two families is typically represented by the true mackerels (*Scomber*), and is characterized by the oblong or slightly elongated form of the body — which is but very slightly compressed, and covered either with very minute scales, or naked — and the structure of the dorsal fins. The first of these may be either modified into free spines, or an adhesive disc, or the posterior dorsal, together with the anal, is split up into finlets. There may or may not be an air bladder. Characterized by their beautiful protective coloration, which is some shade of bluish green, mottled or barred with black above, and iridescent silver beneath, the members of this family are all pelagic and carnivorous fish, associating in shoals, which may be of immense size, and frequenting all tropical and

temperate seas. To enable them to keep up their constant rapid movements, their muscles, which are consequently red in color, receive a much more abundant supply of blood than is the case with other members of the class, and their temperature is thereby raised several degrees higher. Although spawning in the open sea, at certain times of the year they make periodical migrations toward the shore in pursuit of the shoals of herrings and their fry on which they so largely subsist. In time, the family dates from the lower Eocene deposits of Switzerland, where it is represented by several extinct genera, and likewise by a species of sucking fish; while many of the other existing genera occur in the latter deposits.

The true mackerels are characterized by the first dorsal fin being continuous, with feeble spines; the presence of five or six finlets behind the dorsal and anal; the very small scales, which are evenly distributed over the body; the small size of the teeth; and the two short ridges on each side of the caudal fin. Although there are but very few species of mackerel, these have a very wide range; and the genus is represented throughout the temperate and tropical seas, with the exception of the Atlantic seaboard of temperate South America. The general coloration and form of mackerels are too well known to call for description, and it will suffice to mention that of the three European forms the common mackerel (*S. vernalis*)* has no air bladder, while the southern mackerel (*S. pneumatophorus*) takes its name from the presence of that organ, which likewise exists in the Spanish mackerel (*S. colias*). In a fossil condition this genus occurs in the European Eocene and Miocene deposits. Of the common mackerel, which is represented in the upper figure of the illustration on p. 2732, Yarrell writes that "the ordinary length varies from fourteen to sixteen inches, and their weight is about two pounds each; but they are said to attain the length of twenty inches, with a proportionate increase in weight. The largest fish are not, however, considered the best for table. As an article of food, they are in great request; and those taken in the months of May and June are generally considered to be superior in flavor to those taken either earlier in the spring or in autumn. To be eaten in perfection, this fish should be very fresh." The enormous takes of mackerel which occasionally reward the labors of British fishermen are too well known to need mention.

Tunnies

Under this general title may be included not only the fish to which the name tunny (*Thynnus mediterraneus*) properly pertains, but likewise those commonly designated bonitos and albicores. The genus, which comprises some of the largest of all pelagic fishes, differs from the true mackerels by the greater number (six to nine) of finlets, by the scales forming a kind of corselet on the anterior part of the body only, and the presence of only a single longitudinal ridge on each side of the tail. The tunnies have a geographical distribution coextensive with that of the family; and in a fossil state are found in the Eocene and Miocene deposits of the Continent. The common species, which attains a length of over ten feet, and a weight of half a ton, is an occasional visitor to the British coasts, and is abundant in the Mediterranean, where it has been regularly fished for since very early times. At the present day specimens of a hundredweight

*The author can neither admit the combination *Scomber scomber* as the title of this fish, nor that of *Thynnus thynnus* for the tunny.

each may often be seen in the Lisbon market; their flesh, which is as red as beef, being cut up and sold by weight. The bonito (*T. pelamys*) is a smaller and more slender fish, rarely exceeding a yard in length, and frequenting all temperate and tropical seas; while the name of albicore is applied to species like *T. albicora* of the Atlantic, characterized by the great length of their pectoral fins, some of these fish attaining a length of six feet. Albicore and bonito will follow in the wake of sailing ships for weeks together. They prey largely on flying fish; and Bennett writes of one species that it was interesting "to mark the precision with which it swam beneath the aëronaut, keeping him steadily in view, and preparing to seize him at the moment of his descent. But this the flying fish would often elude by instantaneously renewing his leap, and not unfrequently escape by extreme agility." Moseley writes that, when at St. Vincent, he saw a tunny of some twenty-five pounds in weight attracted by baits thrown into the water by some negroes, who kept on casting in fresh ones for some time, in order to give their victim confidence. "A very strong piece of cord, with a hook like a salmon gaff made fast to it, was then baited with a small fish, just enough to cover the point of the hook, and a stout bamboo used as a rod. The cord was hitched tight round one end of it, with about a foot of it left dangling with the hook. One negro held the rod, and another the cord, the bait being held just touching the surface of the water. The fish swam up directly, and took it; the negro holding the bamboo struck sharply, and drove the big hook right through the fish's upper jaw, and both men caught hold of the line and pulled the fish straight out on to the rock." This instance indicates the remarkable boldness and voracity of the tunnies, the fish in question not being six feet distant from the negro holding the pole when it took the bait. Passing over several allied genera, such as *Pelamys* and *Cybium*, we proceed to a more interesting group of the family.

Sucking Fishes

The remarkable adhesive disc on the upper surface of the head at once serves to distinguish the sucking fishes, not only from their immediate relatives, but likewise from all other members of the class; and it may be mentioned that the development of this disc by means of what is called natural selection presents one of the strongest objections to the acceptance of that doctrine, since in its incipient stages such a structure would be utterly useless. The genus *Echeneis*, to which all the half-score species of sucking fish pertain, differs from all those noticed above in the absence of finlets; the sucking disc being formed by a modification of the spines of the dorsal, and being composed of a number of transverse plates, varying from twelve to twenty-seven, according to the species. It is not a little remarkable that there exists in the Indian seas, as also in the tropical Atlantic, a fish (*Elacate nigra*) closely allied to the sucking fishes, but with the disc represented by a few short and separated spines; and it may be considered certain that this fish is the survivor of the ancestral type from which its more specialized relatives have been evolved. The body of the sucking fishes is elongate and pyriform; the eyes are lateral, or directed downward and outward; and the cleft of the mouth is deep. Villiform teeth are present, not only in the jaws and on the bones of the palate, but generally also on the tongue; the scales are minute; and there is no air bladder. The second dorsal and anal fins are elongated, and the pel-

vics thoracic in position. Both in this genus and *Elacate* the shape of the caudal fin is subject to considerable change with age; the middle portion in the young being produced into a long filament, which gradually shortens until a rounded margin is produced. At the time of the full development of the fish the corners of the tail have, however, grown out, so as to convert the rounded fin into an emarginate or forked one. Of the two most common members of the genus *Echeneis remora*, which is the one represented in our illustration, is comparatively small, growing only to a length of about eight inches; whereas *E. naucrates*, characterized by the



SUCKING FISHES.
(Two-thirds natural size.)

slenderness of its form, may reach a yard in length. Sucking fishes are inhabitants of nearly all seas, and in a fossil state are found in the lower Eocene deposits of Switzerland.

Sucking fishes are commonly found attached to the bodies of sharks, although they may affix themselves either to turtles or ships; and as they are carried by their involuntary hosts through a much greater extent of water than their limited powers of swimming would admit of their traversing by themselves, they naturally obtain a much greater supply of food than would otherwise be possible. The erection of the plates constituting the sucker produces a series of vacua, by means of which the adherence is effected; and so strong is the adhesion that it is very difficult to remove one of these fishes except by sliding it along the surface to which

it is attached. Moseley remarks that in shark fishing the suckers sometimes drop off as the shark is hauled on board, and sometimes remain attached; and that when a shark is hooked and struggling in the water, they may often be seen to shift their position. He adds that as it is the back of the sucking fish that is applied to the body by which it is transported, this "being always less exposed to light is light colored, whereas the belly, which is constantly outermost and exposed, is of a dark chocolate color. The familiar distribution of color existing in most other fish is thus reversed. No doubt the object of this arrangement is to render the fish less conspicuous on the brown back of the shark. Were its belly light colored, as usual, the adherent fish would be visible for a great distance against the dark background. The result is that when the fish is seen alive, it is difficult to persuade oneself at first that the sucker is not on the animal's belly, and that the dark exposed surface is not its back. The form of the fish, which has the back flattened and the belly raised and rounded, strengthens the illusion. When the fish is preserved in spirits, the color becomes of a uniform chocolate and this curious effect is lost. When one of these fish, a foot in length, has its wet sucker applied to a table, and is allowed time to lay hold, it adheres so tightly that it is impossible to pull it off by a fair vertical strain." When they have lost their shark these fish often attach themselves to a ship, which they probably mistake for a large individual of that race. It has been stated that certain races are in the habit of employing sucking fishes for the capture of turtles. This curious mode of fishing is practiced by the natives of Zanzibar, Cuba, and Torres Straits.

Stargazers and Weavers — Family *Trachinidæ*

According to the arrangement adopted by Dr. Günther, the eighth family of the group under consideration is taken to include not only the typical weavers, but likewise the stargazers and several other more or less nearly allied types, these being split up into five subfamilies. On the other hand, Day prefers to regard some if not all of these subfamilies as the representatives of distinct families; but in a work of the present nature it will be more convenient to treat the whole of them together. In this wider sense the family is characterized by the more or less elongated and narrow form of the body, which may be either naked or have scales. A spinous dorsal, or a spinous portion of the dorsal, is generally distinct, in which the spines are connected by membrane; there are no finlets; the caudal (except in the tilefish) is not forked; the pelvic fins include a single spine and five rays; and the gill openings are more or less wide. The number of verbtebræ in the trunk is generally ten or more, and there are always more than fourteen in the tail. As a rule, the members of this family agree with those of the preceding families of the group in the absence of a bony stay connecting the preopercular bone with the orbit, but in the genus *Pseudochromis* and its allies such a connection exists. Carnivorous in their habits, the majority of these fishes are of small size, with but feeble swimming powers, and living on the bottom of shallow seas. The tilefish and its allies are, however, large deep-water forms: and the genus *Bathydraco* has

been taken from depths of over twelve hundred fathoms. They inhabit all seas except the Arctic, where they are are almost unknown.

Stargazers

The stargazers as typically represented by the genus *Uranoscopus*, of which one species (*U. scaber*) is shown in the upper figure of the accompanying illustration, form the first subfamily, and take their name from the upward direction of their small eyes, which are situated on the upper surface of the head. They are further characterized by the continuous lateral line, and by the spinous portion of the single or double dorsal fin being less developed than the soft



STARGAZER AND WEAVER.
(One-third natural size.)

part, which is similar to the anal. The members of the typical genus are distinguished by the large, broad, and massive head being partly covered with bony plates; the vertical cleft of the mouth; and the minute size of the scales. The first of the two dorsal fins has from three to five spines, and the rays of the pectorals are branched. Villiform teeth are present in the jaws and on the bones of the palate, but there are no tusks. The gill cover is armed; and there is generally a long filament below or in front of the tongue, but there is no air bladder. While the figured species is from the Mediterranean, the others range from the Indo-Pacific to the Atlantic. Rarely measuring a foot in length, these exceedingly unprepossessing

fish can raise or depress their small eyes at will, and are generally found lying sluggishly on the sea bottom in wait for their prey, frequently concealed among stones. The filament in front of the mouth, which is moved by the stream of water continually passing through the latter, doubtless acts as a lure to entice the small creatures on which these fishes feed. In the allied *Leptoscopus* of New Zealand, and *Ichthyoscopus*, ranging from India to Japan, there is but a single dorsal fin; the latter genus agreeing with the true stargazers in having bony plates on the head, whereas in the former the whole head is invested in a smooth skin. The Indian *I. inermis* attains a length of two feet, and is stated to live in the mud.

Weavers

The common English weaver or stingbull (*Trachinus draco*) shown in the lower figure of the illustration on p. 2743, is the best-known representative of the typical genus of the second subfamily, in which the eyes are more or less lateral in position, the lateral line continuous, and the hinder part of the premaxillary bone devoid of an enlarged tooth; the dorsal fins being one or two in number. In this particular genus the cleft of the mouth is very oblique; the eyes have an upward inclination; the cycloid scales are very small; and there are villiform teeth both in the jaws and on the bones of the palate. Of the two dorsal fins, the first is very short and furnished with six or seven spines; and the lower rays of the pectorals are simple. In the head both the preorbital and preopercular bones are armed. The weavers have a somewhat peculiar geographical distribution, being found in the European seas, but unknown on the Atlantic coasts, although reappearing in Chilian waters. In the British seas they are represented by the greater weaver (*T. draco*), frequently measuring about a foot in length, and the lesser weaver (*T. vipera*), which seldom exceeds six inches. Yarrell writes that "the great weaver generally measures about twelve inches in length, but has been known to attain seventeen inches; its food is the fry of other fishes, and its flesh is excellent. It swims very near the bottom, is sometimes taken in deep water by the trawl net, and occasionally with a baited hook attached to deep-sea lines. When caught it should be handled with great caution. I have known, says Mr. Couch, three men wounded successively in the hand by the same fish, and the consequences have been in a few minutes felt as high as the shoulder. Smart friction with oil soon restores the part to health, but such is the degree of danger, or apprehension of it rather, arising from wounds inflicted by the spines of the weavers, that our own fishermen almost invariably cut off the first dorsal fin and both opercular spines before they bring them on shore." The poisonous secretion, which is a modification of the ordinary mucus, is lodged in a deep double groove in the spines of the dorsal fin and gill cover. There are numerous other genera of the subfamily, among which the above-mentioned *Bathydraco* is noteworthy as being a deep-sea fish.

Tilefish

The third subfamily — regarded by many writers as a distinct family under the name of *Latilidæ* — has been long known by the genera *Latilus* and *Pinguipes* from various tropical and subtropical seas, and is characterized by the body being covered with small scales, the lateral position of the eyes, the continuous lateral line, and the presence of a large tooth on the hinder part of the premaxillary bones. Especial interest attaches to the group, on account

of the discovery of a new member off Noman's Land, Massachusetts, in 1879, which received the name of tilefish (*Lopholatilus chamæleonticeps*). An interesting account of this fish is given by Mr. B. Phillips, who, after mentioning that the first example was taken by the captain of a fishing smack when working cod lines in deep water, goes on to observe that the tilefish was one of the most brilliantly-colored fishes out of the tropics, and remarkable for the presence of a soft dorsal fin, resembling that of the salmon, which is placed on the neck in advance of the regular dorsal fin instead of behind it, as in the salmon family. In the United States Fishing Report of 1881, it is stated that "there is every reason to believe that the tilefish will rank among the most important food fishes of the United States." The fish would weigh from ten pounds to forty pounds, and its abundance was remarkable. It took the hook readily, and in an hour or two a catch of two hundred and fifty



TILEFISH.

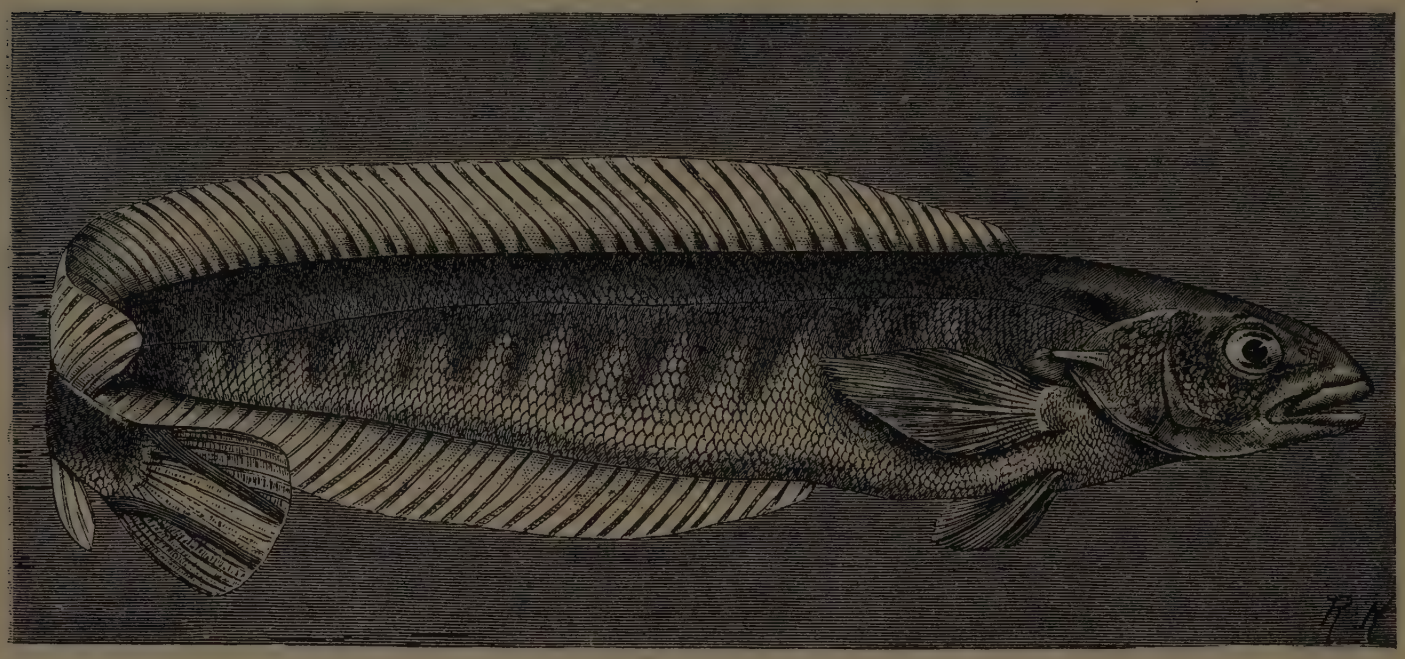
pounds of tilefish was not uncommon. As the lines used were the same as for cod fishing, no change of apparatus was necessary. It was then believed that this new fish would singularly increase the food supply of the North Atlantic coast; but just when the fishermen were beginning to apply their skill to the catching of tilefish off the New England coast, the *Lopholatilus* disappeared.

Other Groups

Two other subfamilies, distinguished by the lateral line being interrupted or stopping short of the caudal fin, are severally typified by the genera *Pseudochromis* and *Notothenia;* the former subfamily having the dorsal fin continuous, while in the latter it is divided. *Pseudochromis* and certain other genera include tropical fish frequenting coral reefs or coral coasts, and taking their name from their superficial resemblance to the members of a very different family — the *Chromididæ*. They differ from all the allied forms in having a bony stay connecting the preopercular bone with the infraorbital ring.

Soft Spines and Frogfishes — Families *Malacanthidæ* and *Batrachidæ*

Of these two unimportant families, the first is represented solely by the soft spines (*Malacanthus*), and differs from the preceding family by having only ten trunk and fourteen tail vertebræ. The body is elongated, and covered with very small scales; the mouth has very thick lips; and the premaxillæ have a large tooth behind. The dorsal fin is single, and, like the anal, greatly elongated; its anterior portion having a few simple rays. There is one spine to the five-rayed pelvic fins; and the gill membranes are united beneath the throat, the gill cover being armed with a spine. Of the three tropical species constituting this genus, the one here figured (*M. hœdti*) is distributed through the Indian and Pacific Oceans, from Mauritius to the Sandwich Islands; the second has a nearly similar range; but the third is found on the Atlantic coast of tropical America.



HŒDT'S SOFT SPINE.
(Two-thirds natural size.)

Frogfishes

Frogfishes (*Batrachus*) may be taken as our representatives of the second of the two families under consideration. The family to which they belong is characterized by the distinct spinous portion of the dorsal fin, which includes a few pungent spines; while the pelvic fins have one spine and only two soft rays. The head is broad, thick, and frog-like; the body elongate, and compressed behind; and the skin either completely naked, or covered with small scales; the conical teeth being of small or medium size. The soft dorsal and anal fins are elongated, and the pectorals simple; the rather narrow gill opening forming a more or less nearly vertical slit in advance of the latter, and the opercular bones being armed. An air bladder is invariably present. All the members of the family are of small size and carnivorous habits, living on the sea bottom and often ascending tidal

rivers; but, while the majority are confined to the tropics, a few range into the warmer parts of the temperate zones. As a genus, the true frogfishes are characterized by the spinous portion of the dorsal fin having three strong spines, and the presence of several spines on the gill cover; while in many species the margins of the mouth, as well as other parts of the head, are provided with shining tentacles. Out of about a dozen species, one (*B. didactylus*) occurs in the Mediterranean. Some of the species have a poison gland under each pectoral fin; and at Penang all the tribe are regarded as highly poisonous, although in Bombay their flesh is eaten by the poorer classes of natives. The poison gland attains its highest development in a species from the Pacific coast of Panama, described under the name of *Thalassophryne*, in which it is stated to be as perfect as in the venomous snakes. In this fish each opercular bone terminates in a long spine similar to those of the dorsal fin; these spines being perforated by a canal having an aperture at their base and summit. This canal communicates with a sac containing the poisonous secretion, which can be made to flow out through the spine by pressure.

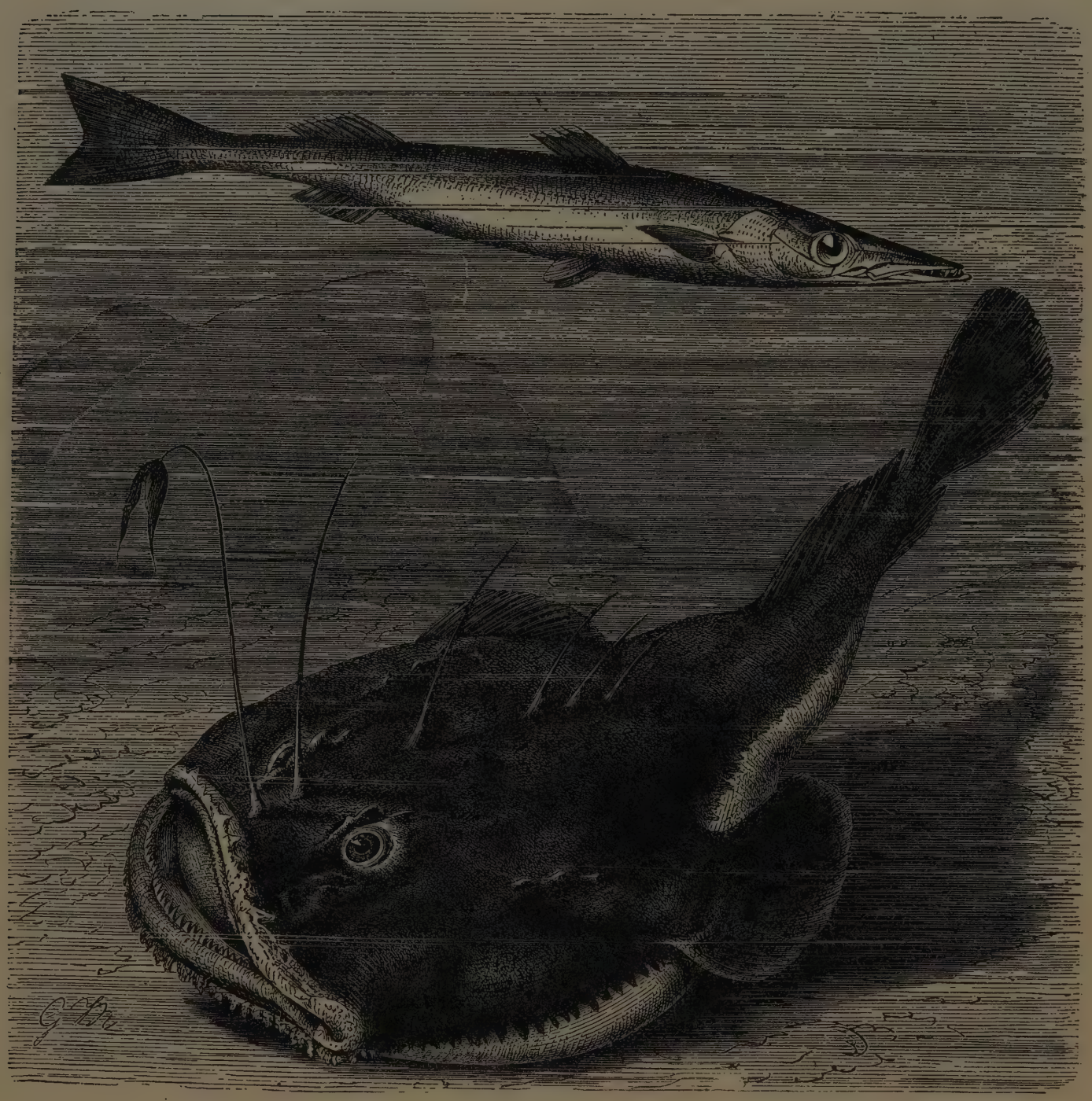
Angler Fish and their Allies — Family *Lophiidæ*

Passing over one very unimportant family, our next representatives of the group under consideration are the angler fish and their allies; a family remarkable for their extreme ugliness and strange forms. Possessing the group characeristics already noticed, they are specially distinguished by having the spinous dorsal fin placed far forward on the head, and generally modified more or less completely into tentacles, although it may be represented by isolated spines. The head and fore part of the body are of enormous relative size, and the teeth in the capacious mouth are either villiform or rasp-like. When present, the pelvic fins consist of four or five soft rays; and the pectorals are supported by a prolongation of some of the superior bones. The gill opening is reduced to a small aperture situated near the pectoral fin; and the gills themselves are either two and a half or three and a half in number, false gills being generally absent. These fish are distributed over all seas. Dr. Günther writes that "the habits of all are equally sluggish and inactive; they are very bad swimmers; those found near the coasts lie on the bottom of the sea, holding on with their arm-like pectoral fins to seaweeds or stones, between which they are hidden; those of pelagic habits attach themselves to floating seaweed or other objects, and are at the mercy of wind and current." A large proportion of the genera have, therefore, found their way to the greatest depths of the ocean, retaining all the characteristics of their surface ancestors, but assuming the modifications by which they live in abysmal depths.

Anglers

The small number of species constituting the typical genus (*Lophius*) of the family include its ugliest representatives, among these being the British angler fish (*L. piscatorius*), which also rejoices in the titles of fishing frog, frogfish, or sea devil. Its leading characteristics are to be found in the enormous size of the broad, depressed, and rounded head, near the middle of the upper surface of which are situated the small eyes; and the great width of the

cleft of the mouth, which looks like a yawning chasm. Both the jaws and palate are armed with rasp-like teeth of unequal size, capable of being raised and depressed at the will of their owner. The body is naked; the first three spines of the dorsal fin form long tentacles on the head; and the next three are connected; the soft dorsal and anal fins being of small length. Young specimens are exceedingly un-



BARRACUDA AND ANGLER FISH.
(One-twelfth natural size.)

like tneir parents, having the head smaller, the tentacles branched, and most of the rays of the fins produced into long filaments. The whole of the few known forms are coast-haunting fishes, the common species ranging from the European and South African seas to those of the western side of North America; while a second is found in the Mediterranean, a third in Chinese and Japanese waters, and a fourth

in those of the Admiralty islands. In the British species the general color of the upper surface is uniform brown, becoming darker on the fin membranes; while the under parts, as well as the pectoral and pelvic fins, are white; the tail being dark blackish brown. The color is, however, subject to a certain amount of modification, according to the tint of the inanimate surroundings of the individual. Although commonly not more than a yard in length, specimens of this ugly monster have been known to measure more than five feet. In all respects the angler affords us an example of a creature most admirably modified and adapted for the exigencies of its particular mode of life. Living on the mud or sand of a shallow sea bottom, the angler is protected not only by its power of adapting its own coloration to that of its environment, but likewise by the fringed appendages surrounding the head presenting the appearance of a mass of seaweed. The structure of the paired fins renders the fish able to walk on the sea bottom; and with these limbs it also stirs up at times the sand and mud to attract its prey, and at the same time to aid in concealing its own ugly person. Fish and other prey are also attracted by the constant movement of the first tentacle on the head, the summit of which terminates in an expanded lappet; and no sooner is the unfortunate victim well within reach, than it is engulfed with one snap of the capacious mouth; the erectile and backwardly-directed teeth preventing any chance of escape from this avernus.

Tentacle Fish

As an example of a pelagic genus of the family we select the tentacle fish (*Antennarias*), so remarkable for their nest building habits. In these fishes the large head is elevated and compressed; the cleft of the mouth being quite or nearly vertical, and of only moderate width. There are rasp-like teeth on the palate and jaws; the eyes are small and lateral; the body may be either naked, or covered with granules or spines, which may be modified into tentacles; and the head is furnished with three tentacles very similar to those of the true anglers. The soft dorsal is of moderate length, and the anal short; pelvic fins being present. Although chiefly tropical, these fishes are often carried far into the temperate seas; and many of them have a most extensive range, being found alike in the Pacific and Atlantic Oceans. Feeble swimmers, these fishes are not unfrequently to be found near the coast, where they conceal themselves beneath corals, stones, or seaweed, to which they hold fast by their arm-like pectoral fins. They have also been observed to hop over moist ground or slimy seaweed, and at times conceal themselves in the mud, after the manner of the true anglers, attracting their prey by the movements of the first tentacle on the head, the extremity of which, when in motion, much resembles a worm. When at sea, they have the power of inflating their bodies in the same way as the globe fishes. It has been observed that one of these fishes placed in a basin containing a small quantity of water produced so strong a current by the passage of water through its jaws, and its subsequent expulsion through the gill orifice, that a rapid rotatory motion resulted. "The gulf weed," writes Day, "assists the migration of these fishes; during the winter months the prevailing winds bring to the islands of the Bermudas large fields as well as isolated patches of weed, on which many fishes find a home, and among them *Antennarias*. Here it makes its wonderful nest, suspended by means of silk-like fibres, which prove strong enough to support the huge bunches of eggs

that hang like grape clusters within its orbicular case; and M. Vaillant has shown that each nest is made of one seaweed, the different twigs being brought together and made fast to each other by the fish by means of a pasty sort of substance provided by the animal itself."

The Bullheads and Gurnards — Family *Cottidæ*

The thirteenth family of the present section differs from all the foregoing, with the exception of the genus *Pseudochromis* and its allies, in the presence of a bony process arising from the infraorbital ring of the skull to connect it with the spine at the angle of the preopercular bone. In shape the body is more or less elongate and subcylindrical; the cleft of the mouth is transverse, and the weak teeth are generally arranged in villiform bands. As a rule, there are two dorsal fins, of which the spinous is less developed than the soft; both the latter and the anal being elongated; the pectorals may be provided with filamentous appendages, and the pelvic pair have not more than five rays. The body may be either naked, scaled, or protected by a single row of plate-like scales. The members of this family, which are arranged under a good many generic heads, are distributed over almost all seas, while a few inhabit fresh waters. Of comparatively-small or medium size, these fishes have but poorly developed swimming powers, and spend their time swimming or crawling at the bottom of the sea in shallow water at no great distance from the coast. A Japanese bullhead is stated, however, to have been dredged in five hundred fathoms of water. In a fossil state gurnards referable to the existing genus occur in many of the European Tertiary rocks; while remains of bullheads are met with in the upper Miocene of Basle, and those of the allied extinct genus (*Lepidocottus*), distinguished by its ctenoid scales, in the upper Eocene of Switzerland.

Bullheads

The familiar bullhead or miller's thumb (*Cottus gobio*) of the streams of Britain and many other parts of Europe, belongs to a genus containing some forty species, mostly distributed over the fresh waters and coasts of the temperate zone of the Northern Hemisphere. All are of small size, and characterized by the broad, depressed, and rounded heads; the subcylindrical body, somewhat compressed posteriorly; the absence of scales; the distinct lateral line; and the rounded pectoral fins, in which some or all of the rays are simple. Villiform teeth are present on the jaws and vomer, although there are none on the palatine bones. In the majority of the fresh-water species the spine on the preopercular bone is simple, but becomes branched in many of the marine forms. The common fresh-water species, which ranges over Central and Northern Europe to Northern Asia, seldom exceeds four or five inches in length, and is more generally found in small streams than in large rivers. It has a well-known habit of concealing its broad and flat head beneath loose stones on the river bottom, and in this position will lie motionless for hours, but when disturbed swims swiftly away. Its food consists of the larvæ of water insects and crustaceans, as well as the eggs and fry of other small fish. The other British representatives of the genus are all marine, and include the sea scorpion (*C. scorpius*) and father-lasher (*C. bubalis*), both of

which are also found on this side of the Atlantic, as well as two other less common species. The males of the common marine species are stated to build a nest of stones and seaweed for the reception of the spawn; and to guard and defend the young fry when hatched.

On the Indian and Australian coasts the bullheads are represented by the so-called flat heads or crocodile fishes (*Platycephalus*) in which the much depressed head is more or less fully armed with spines, and the body covered with ctenoid scales; the anterior spine of the first dorsal fin being isolated from the rest, and



COMMON BULLHEADS
(Natural size.)

teeth present on both the vomer and palatine bones. Day writes of these fishes that "the wounds from their spines are dreaded because of the violent irritation they occasion. Their eyes are peculiar; the iris possesses two semi-circular flaps, one above, the other below, the upper being usually the larger; these flaps can be brought close together, probably under the stimulus of light."

Gurnards

Of a decidedly ugly appearance, the gurnards (*Trigla*) are easily recognized by their enormous, square, and elevated heads, in which the upper surface and sides are entirely bony, and likewise by the finger-like first three rays of the pectoral fins, which serve not only for walking on the sea bottom

but likewise as organs of touch. There are two dorsal fins, of which the spinous is tall, and the soft one long, low, and similar to the anal; the tail fin being slightly rounded. The teeth are villiform; and the air bladder, which is generally furnished with lateral muscles, may be divided into two longitudinal halves. They have been



SAPPHIRINE GURNARDS.
(One-fifth natural size.)

divided into three subgenera, of which the typical one is characterized by the absence of teeth on the palatines, and the small size of the scales, with the exception of the highly modified ones forming the lateral line, which are large, triangular, and spiny. The second group is distinguished by the medium size of the scales;

GURNARDS



while in the third teeth are present on the palatine bones. Their colors are frequently brilliant, and the fins highly decorated. The genus is represented by some forty species, distributed over all temperate and tropical seas, out of which no less than seven are found in British waters. Their flesh, which is firm and flaky, and of a pale orange-pink tinge, is extensively used as food. One of the best known of the British species is the red gurnard (*T. pini*) which seldom exceeds twelve or fourteen inches in length, and, when freshly caught, is of a bright red color, with the sides and under parts silvery white, and the fins reddish white. Its food consists of crustaceans, which give the pinkish tinge to its flesh, and the spawning season is May or June. The sapphirine gurnard (*T. hirundo*), which is the one



ARMED BULLHEAD.
(Two-thirds natural size.)

represented in the cut, is another British species, taking its Latin name from the length of the pectoral fins, and its English title from the beautiful azure tint of their inner surfaces. More abundant than the other species, this gurnard may reach a couple of feet in length, its general color being brownish red. A third British form is commonly known as the piper (*T. lyra*) and may be recognized by the unusually large size of the head, the more projecting muzzle, and the greater length of the spines of the gill cover. The general color is brilliant red, with the under parts white. It attains a length of a couple of feet, and is supposed to take its name from the grunting sound which, in common with other species, it emits when first handled, owing to the escape of air through the mouth. The European

forms are rarely found on this side of the Atlantic, where their place is taken by representatives of the third subgenus.

Two British species are figured in the colored plate, namely, the gray gurnard (*T. gurnardus*) above, and the streaked gurnard (*T. lineata*) below.

The Flying Gurnards and their Allies—Family *Dactylopteridæ*

Another family of the present section is typified by the so-called flying gurnards, and is easily recognized by the investiture of the body in an armor of bony-keeled plates or scales. In form the body is elongate and subcyclindrical; the teeth are weak; and there is a bony stay connecting the preopercular with the infraorbital ring. These fishes are all marine, some being pelagic, and they are found in all



BEAKED GURNARD.
(One-third natural size.)

seas, from the Arctic Ocean to the Equator, as well as in the Southern Hemisphere. They are represented by an extinct genus (*Petalapteryx*) in the Italian middle Eocene.

Agonus

The curious-looking fish (*Agonus cataphractus*), figured in the preceding illustration, is the British representative of a genus of small-sized fishes inhabiting the northern temperate seas and extending into the Arctic Ocean. They are characterized by the angulation of the head and body, which are invested in body plates; the small size of the teeth in the jaws; the two dorsal fins; and the absence of appendages to the pectorals. Of the armed bullhead, as the British species is popularly termed, Yarrell writes that it is not "un-

common along the line of our southern coast, where it is well known; and the young of small size are frequently taken by the shrimpers in most of the sandy bays at the mouth of the Thames and of other rivers; on the eastern coast it is very plentiful. It seldom exceeds six inches in length; its food is aquatic insects and crustaceans; it spawns in May, depositing the ova among stones, and its flesh is said to be firm and good." Somewhat curiously, an outlying representative of the genus occurs on the Chilian coast.

Beaked Gurnards

As a genus remarkable for the singularity of their form we may briefly notice the beaked gurnards, of which the European representative (*Peristethus cataphractum*) is shown in our illustration. These rather small fishes are specially characterized by the preorbital bone being prolonged into a flattened process projecting on each side beyond the muzzle; the whole of the squared head being invested in a solid bony case. Large plates of bone form the body armor; the dorsal fin may be either continuous or divided into two moieties, of which the second is the longer; there are two free appendages in advance of each pectoral fin; teeth are wanting, and the lower jaw is provided with barbels. These fishes, of which there are some ten representatives, range from the southern shores of Britain, through the Mediterranean and Atlantic, and likewise from the Indian Ocean to China and the Sandwich islands. Nowhere abundant, they are believed to inhabit deeper water than the gurnards, which they resemble in their general mode of life.

Flying Gurnards

Of more interest than either of the preceding are the so-called flying gurnards (*Dactylopterus*) of the Mediterranean, the tropical Atlantic, and Indo-Pacific Oceans, since they alone share with the true flying fish the power of taking long flying leaps along the surface of the sea. In order to do this, their pectoral fins are greatly developed, assuming a wing-like form, with the anterior portion shorter and separated from the remainder. The upper surface and sides of the squared, gurnard-like head are bony; long spines are present on the scapular and preopercular; the body is covered with medium-sized keeled scales, among which there is no lateral line; and the second dorsal fin but slightly exceeds the first in length. Although granular teeth are present on the jaw, the palate is toothless. The air bladder is divided into longitudinal halves, and furnished with a muscle. It is only in the adult that the pectoral fins are sufficiently developed to enable these fishes to "fly." Of the three species, the best known is *D. volitans*, which may be commonly met with in the Mediterranean. Very similar in their habits to the true flying fish, the flying gurnards are more heavily built, and measure as much as eighteen inches in length.

Dragon Fishes

In this place may be noticed the curious little dragon fishes (*Pegasus*) from the Indian, Chinese, and Australian seas, which although referred by Dr. Günther to a distinct family are included by Day in the present one. In these strange little fishes the broad and depressed body is covered with bony plates, which are movable, although those investing the tail are firmly welded together. The narrow gill opening is situated in front of the pectoral fin; the gill cover is formed of a single plate, and the gills themselves are four in number. The single short dorsal fin is placed opposite an anal of similar size; the

pectorals are long, horizontal, and composed of simple rays, some of which may be spinous; and the pelvis comprises one or two rays, the outer one being elongated. Both teeth and an air bladder are wanting. The figured species (*P. natans*) is an Australian one, and is less known than the Indian *P. draco* and the Chinese *P. volens;* dried specimens of the latter being familiar objects on Chinese insect boxes. Nothing seems to have been ascertained as to the habits of these fish, although it has been suggested that they probably frequent sandy shores. With this family we take leave of the great Cotta-Scombriform section, as it is called, and pass on to another containing only two or three families.



AUSTRALIAN DRAGON FISH.
(Natural size.)

The Lumpsuckers — Family *Cyclopteridæ*

With the lumpsuckers we come to a small section characterized by the spinous dorsal fin being short, and either composed of flexible spines, or much less developed than the soft dorsal, or soft portion of the same; the soft dorsal being equal in extent to the anal. If present, the pelvic fins are either thoracic or jugular in position, with one spine, and generally five (rarely four) soft rays. There is a prominent papilla in the neighborhood of the vent. In no case is there a bony stay to the preopercular from the infraorbital ring. As a family, the lumpsuckers are characterized by the thick or oblong body, which may be either naked or tuberculated; the small teeth; and the presence of a circular adhesive disc on the lower surface of the chest, surrounded by a fringe of skin, and supported by the rudimental pelvic fins, the gill opening being narrow. All the members of the family, which are arranged under two genera, are carnivorous and coast-dwelling fishes, restricted to the colder seas of the Northern Hemisphere, and ranging into the Arctic Ocean. They derive their name from their habit of attaching themselves to rocks by means of the adhesive disc.

The members of the typical genus *Cyclopterus* are ugly "lumpy" fishes, with the thick, short body covered with a viscous tuberculated skin; the large head has a very short, blunted muzzle; and there are rows of villiform teeth in the jaws, but none on the palate. The skeleton is remarkable for its softness, owing to the small amount of mineral matter entering into the composition of the bones. In the British species (*C. lumpus*), represented in the upper figure of the accompanying illustration, the skin is so thick as to almost conceal the first dorsal fin; and in the adult the large rough tubercles are arranged in four longitudinal series on each side of the



LUMPSUCKER AND VIVIPAROUS BLENNY.
(One-third natural size.)

body. In the young, however, these tubercles are not developed. Although these fishes may reach a length of a couple of feet, they do not usually measure more than twelve or fourteen inches. Yarrell writes that "in the month of March the colors of the lumpfish are in the highest perfection, combining various shades of blue, purple, and rich orange." These voracious fishes feed chiefly on the fry of other species. In the Arctic lumpsucker (*C. spinosus*) there are large, conical bony plates, surmounted with a spine, on the head and body of the adult. In the allied *Liparis* the skin is naked, and more or less loose.

The Gobies and Mud Skippers — Family *Gobiidæ*

The gobies and their allies differ from the preceding family in that there are always distinct rays to the pelvic fins; although in some cases the two fins may be joined in the middle line. Elongated in form, the body may be either scaled or naked; and the teeth are generally small, but may have enlarged tusks among them. The spinous portion of the dorsal (whether separate or continuous with the soft dorsal) is always composed of flexible spines, and shorter than the soft dorsal. The gill opening is more or less narrowed, and there is usually no air bladder. This very



FRESH-WATER GOBY.
(Natural size.)

extensive family comprises littoral fishes of small size and carnivorous habits, a few of which have accustomed themselves to a fresh-water life. It contains a large number of genera, some of which are extremely numerous in species, as are the latter in individuals; and their range includes the coast regions of all the temperate and tropical seas. Geologically, the group is comparatively ancient, true gobies dating from the middle Eocene of Monte Bolca, while the extinct genus *Chirothrix* occurs in the Chalk of the Lebanon.

Gobies

Familiar to all in the person of the common British species *Gobius niger*, the gobies form a very large genus with a geographical distribution as extensive as that of the family, but especially well represented in tropical and subtropical seas, no less than forty different kinds being recorded from those of

India alone. These fishes have the body generally scaled; two dorsal fins, of which the first is usually furnished with six flexible spines; the pelvic fins united to form a disc, which, however, is at most only partially adherent to the abdomen; the teeth in more than a single row; and the vertical gill opening of moderate width. The form of the body is subject to considerable specific variation; and in some forms the head, and in others a part or even the whole of the body is devoid of scales. In some cases there may be barbels or warts on the head, and in others a crest on the occiput. There are likewise considerable differences in the dentition, some species having large tusks among the ordinary teeth. The gobies, of which there are several British marine species, are especially partial to rocky coasts, where they protect themselves against waves and storms by adhering to rocks by means of the sucker formed by their modified pelvic fins; many of them being often found in the swirl of the retreating waves. Some, however, prefer brackish estuaries or lagoons, while others again, like the Russian species (*G. fluviatilis*) represented in our illustration, are exclusively fresh water. In many of them the male constructs a nest in which the spawn is hatched. In the case of the spotted goby, or polewig (*G. minutus*)—a species found for some distance up the Thames—the male when in tidal pools, generally chooses one of the shells of a cockle or some other bivalve for its nest; the shell being placed on the sand with its concave surface downward, beneath which the sand is hollowed out and cemented by a special mucilaginous secretion from the skin of the fish; a cylindrical tunnel giving access to the nest, and the whole structure being covered over with loose sand. The female having deposited her eggs, which are fixed to the shell, in this nest, the male mounts guard over them, maintaining his watch during the whole period of incubation, which lasts from six to nine days. A European goby (*Latrunculus pellucidus*) belonging to a distinct genus, and characterized by its translucent body, is almost peculiar among vertebrates in that its span of life is of only a year's duration. In June and July the spawn is deposited, the eggs are hatched in August, while in the late autumn or winter the fishes become fully mature; these, however die off in the following July or August, so that in September only the fry are to be met with.

Mud Skippers

Omitting all mention of a number of more or less nearly-allied genera, our next representatives of the family are the mud skippers (*Periophthalmus*) remarkable not only for the peculiar physiognomy given them by their conspicuous eyes, but likewise on account of their strange habits. These fishes, which frequent the coasts and estuaries bordering the Indo-Pacific Ocean, and likewise reappear on the shores of West Africa, take their name from their prominent eyes, which are set close together somewhat below the line of the profile, and are not only capable of protrusion and retraction but are furnished with a well-developed outer eyelid. The elongate body is covered with cycloid or slightly pectinated scales, extending on to the bases of the pectoral fins; the cleft of the mouth is nearly horizontal, with the upper jaw projecting somewhat beyond the lower, and the conical teeth are vertical. The first dorsal fin includes a variable number of flexible spines; the base of the pectorals are muscular; the pelvic fins are united for a portion of their length; and the caudal fin has its lower border

obliquely truncated. The species here figured (*P. koelreuteri*) has a wide range, being found in the Red Sea, the seas and on the coast of India, where it ascends tidal rivers and estuaries, as well as in the Andamans, the Malay Archipelago, and the islands of the Pacific. Concerning their habits, Day writes that "these fishes, from the muscular development at the base of the pectoral fins, are able to use them for progression on mud or for climbing. It is a most curious sight to see *P. schlosseri* along the side of the Burmese rivers; at a distance the fishes appear like large tadpoles, stationary, contemplating all passing objects, or else snapping at flies or other insects; suddenly, startled by something, away they go with a hop,



MUD SKIPPERS DISPORTING.
(Two-fifths natural size.)
(After Hilgendorf.)

skip, and a jump, either inland among the trees or on the water like a flat stone or a piece of slate sent skimming by a schoolboy. They climb on trees and large pieces of grass, leaves, and sticks holding on by their pectoral fins exactly as if these were arms. Now and then they plant these firmly as organs of support, the same as one places one's elbows on a table, then they raise their heads and take a deliberate survey of surrounding objects." Of certain allied species, which he places in a genus apart, the same writer remarks that they are essentially mud-dwelling fish, and that if placed in a vessel of deep water they appear to be rapidly drowned. In all, the remarkable prominence of the eyes is more or less completely lost after death. On the slimy banks of the small affluents of the Hughli near

Calcutta, where the writer has often watched their strange habits, these fishes may be seen in hundreds.

Dragonets

Concerning the precise systematic position of the beautifully-colored fishes commonly known as dragonets (*Callionymus*) there is some difference of opinion; Dr. Günther placing them with the gobies, whereas Day, on account of the wide separation of the pelvic fins (which in the latter and their near allies either form a disc or are very close together), refers them to a separate family. Be this as it may, these fishes, in addition to the feature already mentioned, are characterized by the head and anterior portion of the naked body being depressed, while the remainder is cylindrical. The pointed mouth has a narrow horizontal cleft, and a very protractile upper jaw; the large eyes have a more or less upward direction; small teeth are present on the jaws, but none on the palate; and there is a strong spine at the angle of the preopercular. Of the two dorsal fins, the foremost has from three to four flexible spines; the pelvics are five rayed; and the gill opening is very narrow, and generally reduced to a perforation on the upper border of the gill cover. There is a large amount of sexual difference among the dragonets, the adult males having the fin rays produced into filaments and the intervening membranes brightly colored, whereas the females wear a much more sombre livery; and it is due to this variation that there were long supposed to be two British representatives of the genus, namely, the gemmeous, and the sordid dragonet; the former being the male and the latter the female. In the adult male of the common dragonet (*C. lyra*) the first dorsal spine is greatly elongated; the general color of the smooth skin being yellowish, beautifully banded and spotted with lilac; the first dorsal fin bearing several lilac spots, and the second having lilac bands. In length, the male measures about ten inches. The yellow scalpin, as the male is called in some parts of Britain, is generally found in comparatively deep water, whereas the female often approaches the margin of the tide. Both sexes feed on mollusks and other hard-shelled creatures, as well as on worms. Out of some thirty representatives, the majority are inhabitants of the coast regions of the temperate zone of the Old World, although a few are found in the tropical Pacific.

The Blennies and Their Allies — Families *CEPOLIDÆ*, *BLENNIIDÆ*, etc.

The well-known blennies, together with five less important families, constitute a sectional group of spine-finned fishes, all of which may be treated under one heading. As a group, these fishes are characterized by the body being in general more or less nearly cylindrical in form; the dorsal fin is elongated, and its spinous portion, if distinct, is also long, being equal to or even exceeding the soft part in length, while occasionally the whole fin may be spiny; the anal is also more or less elongate; the pelvics, when present, are thoracic or jugular in position; and the caudal fin, which may be absent, is rounded or somewhat truncated.

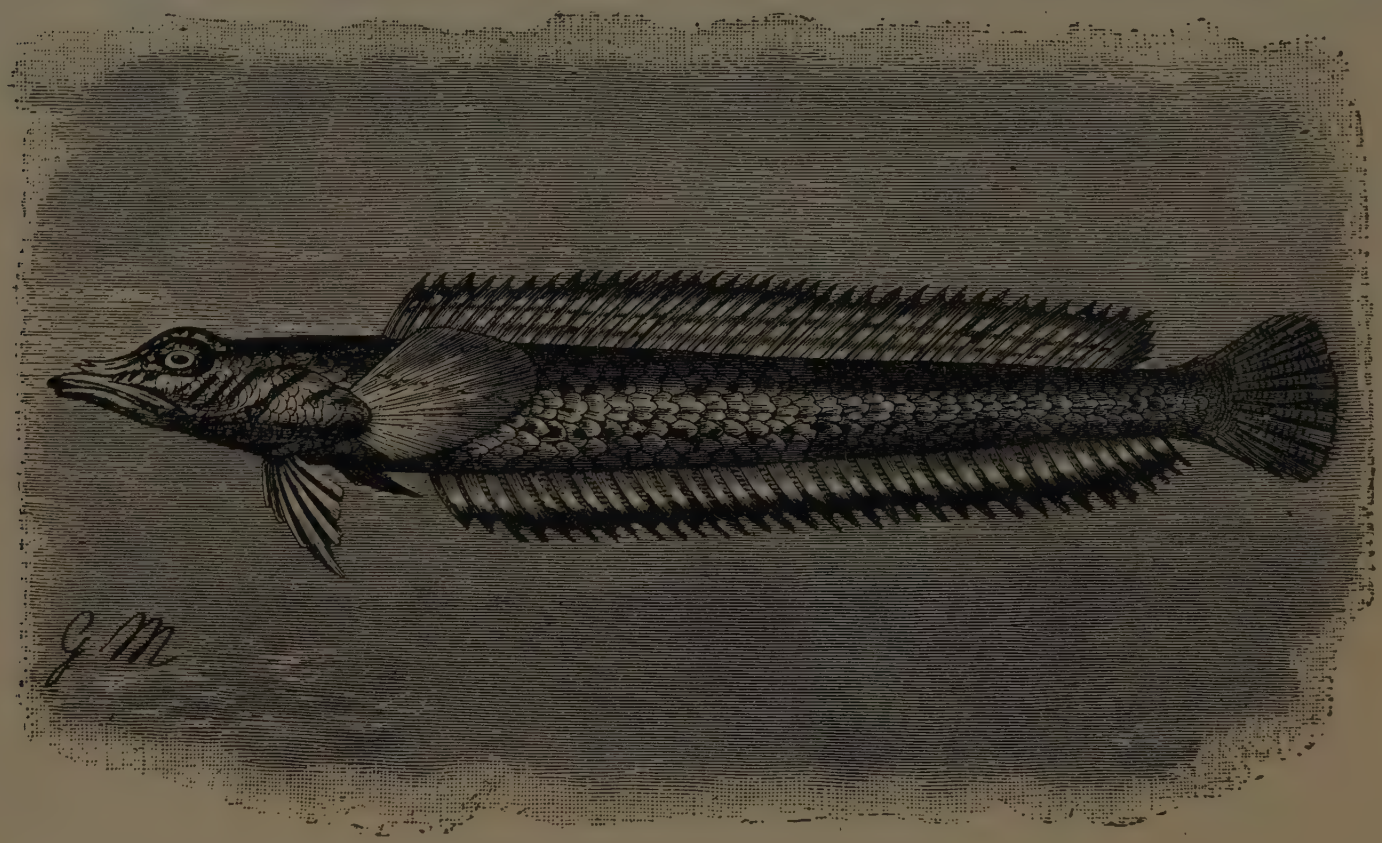
The first family of the group (*Cepolidæ*) is represented by the small marine band fishes, of which one species (*Cepola rubescens*) is a casual visitor to the British

Band Fishes

coasts. The essential characteristics of these fishes are to be found in the elongate and band-like form of the body; the presence of one spine and five soft rays in the thoracically-placed pelvic fins; and the absence of spines in the single dorsal and anal fins. The eyes are rather large and lateral, the teeth of moderate size, and the caudal vertebræ unusually numerous. While the majority of these fishes are confined to the northern temperate seas, a few extend into the Indian Ocean and as far south as Penang.

Hairy Backs

The remarkable fishes known as hairy backs constitute another small family (*Trichonotidæ*) distinguished from the last by the jugular position of the pelvic fins, which are in front of the pectorals; there being one or two spineless dorsal fins, an elongate anal fin, which is also spineless, and no papillæ in the neighborhood of the vent. The typical genus is represented by a single species (*Trichonotus setiger*) from the Oriental seas, characterized by the first few rays



NEW ZEALAND THORNY NOSE.

of the single dorsal fin being isolated and more or less elongate, and likewise by the lower jaw exceeding the upper in length. The New Zealand thorny nose (*Hemerocoëtes acanthorhynchus*) represents a second genus, differing from the last by all the rays of the long dorsal being in juxtaposition, by the upper jaw being longer than the lower, and the presence of horny processes on the muzzle. These fishes are not unfrequently found floating on the surface of the ocean at a considerable distance from land.

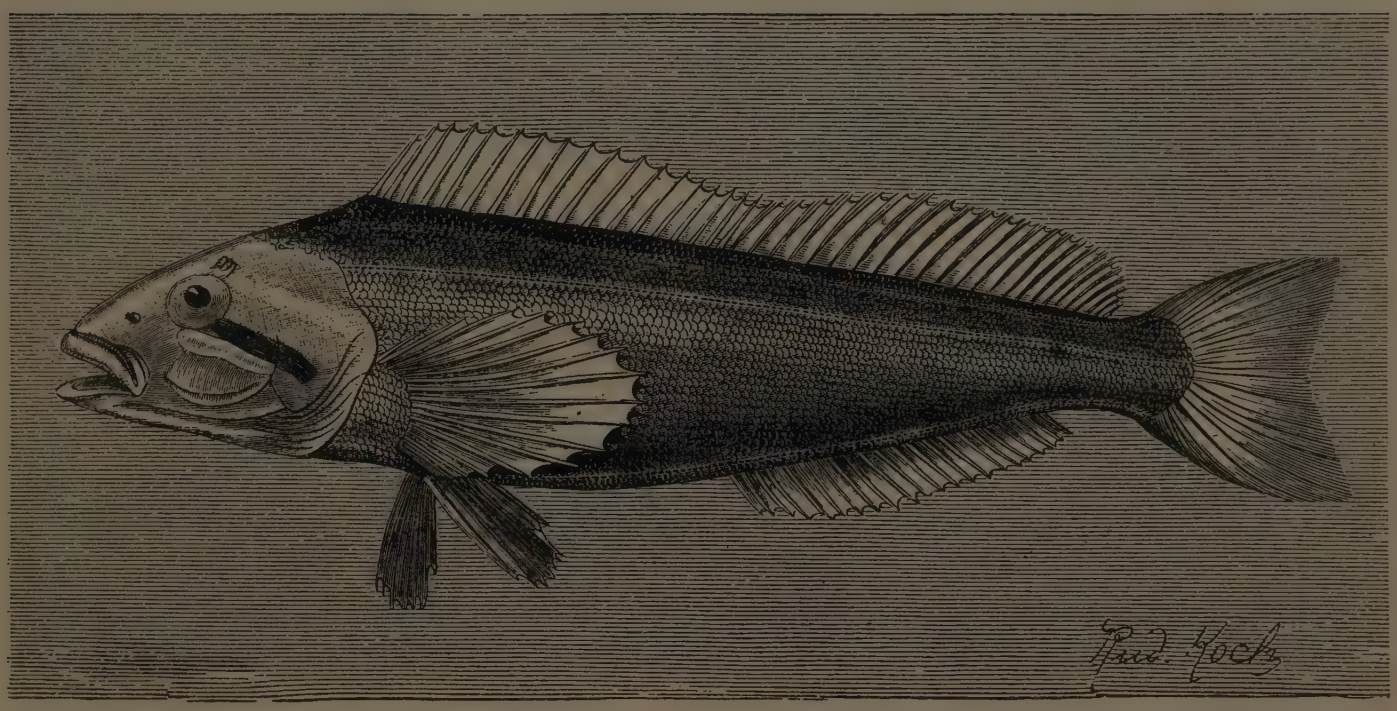
Chirus

The most remarkable representatives of a third small family (*Chiridæ*) of this group constitute the genus *Chirus*, which is peculiar in having several lateral lines, the number of these varying in the different species. The family differs from the two preceding ones in that there is a bony stay connecting the preopercuiar with the infraorbital ring; while it is further distinguished by

the single dorsal having its spinous and soft portions of nearly equal length; the anal being nearly equal in length to the soft dorsal, and the pelvics thoracic in position, with one spine and five rays. The compressed and oblong body is scaled, the cleft of the mouth lateral, and the teeth are weak. All the members of the family are small littoral fishes, inhabiting both sides of the Northern Pacific; the figured species (*Chirus hexagrammus*) being from Japanese waters. In the other genera the lateral line is single.

Blennies

The fourth family of the group (*Blenniidæ*) is much more extensive than either of the others, comprising a considerable number of genera, some of which are rich in species. The family agrees with the hairy backs in the jugular position of the pelvic fins, which, when present at all, are composed of a very few soft rays. In the anal fin, the spines are few or wanting, and there is very generally a papilla in the neighborhood of the vent. The low and elongate



JAPANESE CHIRUS.

body is more or less cylindrical in form, and either naked or covered with scales, which are generally of small size. The dorsal fin, which may be either single, double, or triple, occupies nearly the whole length of the back; and when it has a distinct spinous portion, this is at least as much developed as the soft part, while in some instances the whole fin may be spiny; the anal being elongate. In most cases false gills are present. All the marine members of the family are littoral forms, and the majority are of small size, while some are among the smallest of all fishes. They are abundant throughout all tropical and temperate seas; and whereas some forms inhabit brackish water, others are exclusively fresh water. Dr. Günther writes that "one of the principal characteristics of the blennies is the ventral [pelvic] fin, which is formed by less than five rays, and has a jugular position. The blennies have this in common with many gadoids [cod tribe], and it is sometimes difficult to decide to which of these two families a fish should be referred. In such

doubtful cases the presence of the pseudobranchiæ (which are absent in gadoids) may be of assistance. In many blennies the ventral fins have ceased to have any function, and become rudimentary, or even entirely absent. In others, the ventral fins, although reduced to cylindrical stylets, possess a distinct function, and are used as organs of locomotion, by the aid of which the fish moves over the bottom." The family is not definitely known in a fossil state, although it may be represented by an extinct genus in the Monte Bolca Eocene.

The blennies of the typical genus *Blennius*, of which there are some forty species, are found in the northern seas, the tropical Atlantic, the coasts of Tasmania, and the Red Sea. They are characterized by the moderate elongation of the naked body, the short snout, the single continuous dorsal fin, and the presence of one spine and two rays in the pelvics. The cleft of the mouth is narrow, the jaws contain a single series of fixed teeth, behind which there is generally one larger curved tooth, at least in the lower jaw. Above each eye is the longer or shorter tentacle, and the gill opening is relatively wide. Among British species we have the eyed blenny (*B. ocellatus*) distinguished by the dark spot on the elevated spinous portion of the dorsal, the smooth blenny or shanny *B. pholis*, and the large *B. gattorugine*, which may grow to a foot in length; while as an example of a species living in inland lakes we may cite the fresh-water blenny (*B. vulgaris*) of Southern Europe. Most can be readily accustomed to a fresh-water life, and many of the marine species attach themselves to floating objects, while some are found far out at sea among the patches of drifted seaweed. In the Indian seas the blennies are repesented by seven more or less closely-allied genera, in one of which (*Xiphasia*) the body is band-like, and the caudal fin continuous with the dorsal and anal.

Viviparous Blennies

The fish (*Zoarces viviparus*) of which two examples are represented in the lower part of the illustration on p. 2757, is one of two species of a genus remarkable for producing living young. With an elongate body, rudimental scales, and conical teeth in the jaws, these fish have an extremely-elongated dorsal fin, separated from the caudal merely by a depression formed by a series of spines much shorter than the rays; these spines being the only ones throughout the fins. The pelvic fins are composed of three or four rays; and the long anal fin is continuous posteriorly with the caudal. The gill openings are wide. While the figured European species, which is not uncommon on the British coasts, does not exceed a foot in length, its Transatlantic cousin (*Z. anguillaris*) may measure two or three times as much. The fry, which at birth are perfectly transparent, and form beautiful objects for the microscope, are so fully developed as to be able at once to swim freely on leaving the body of the female parent. Before their birth the female becomes so distended, that at the slightest pressure the young are extruded; these frequently being from two to three hundred in number, and always making their appearance in the world head first. The general color of the adult fish is pale brown, with the dorsal fin and the upper parts mottled and barred with darker brown.

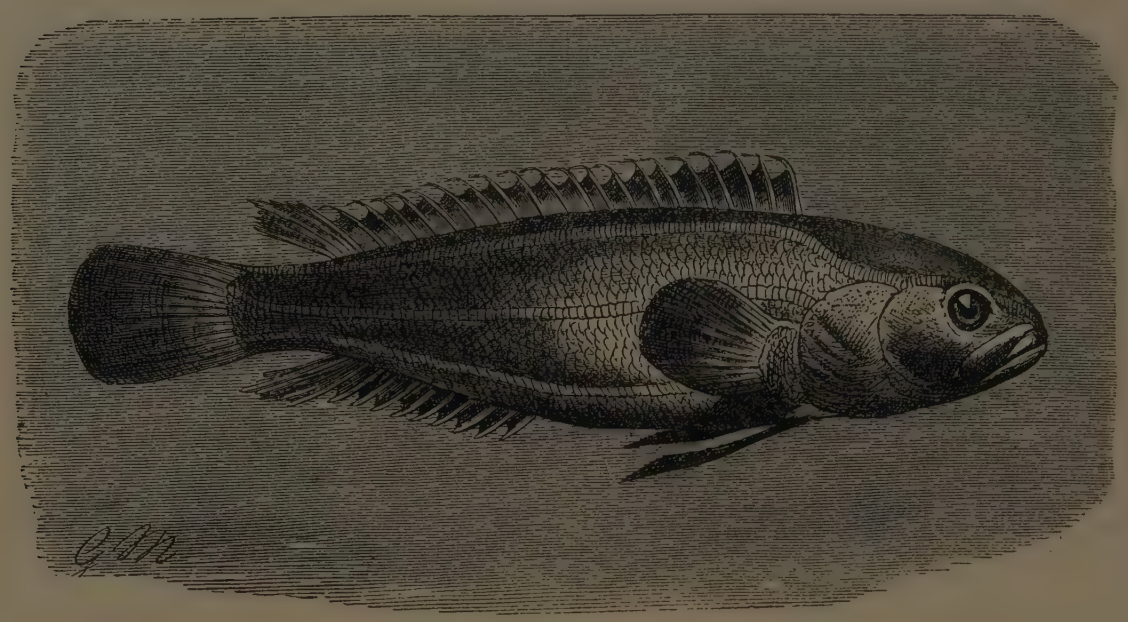
Wolf Fishes

Easily recognized by the powerful tuberculated and molar-like teeth with which their mouths are armed, the wolf fishes (*Anarrhichas*) may be regarded merely as gigantic and somewhat specialized blennies. In this

genus, which is represented by a small number of species from the northern seas of both the Eastern and Western Hemispheres, the elongate body is covered with rudimental scales; the muzzle is rather short and the cleft of the mouth wide; and the jaws are armed with strong conical teeth, those of the latteral series carrying several pointed cusps, while a double row of large molar-like teeth runs down the middle of the palate. The long dorsal fin has flexible spines, and there is a distinct caudal, but the pelvic pair are quite wanting. The gill opening is wide. The common wolf fish (*A. lupus*) often known as the sea wolf or sea cat, like two allied species, ranges as far north as Norway and Greenland; in both of which countries its flesh forms a staple article of food.

Oblique-Spined Blenny

The fifth family (*Acanthoclinidæ*) of the section under consideration is represented only by the New Zealand oblique-spined blenny (*Acanthoclinus littoreus*), shown in the annexed illustration, and is characterized by the elongate, low, compressed, and scaly body, the single dorsal fin — chiefly composed of spines — occupying nearly the whole length of the back, and the comparatively-long and many-spined anal; the pelvic fins being jugular in position, and consisting solely of a few soft rays. On the coasts of New Zealand this blenny is stated to be a very common fish; its habits being probably similar to those of its European cousins.



OBLIQUE-SPINED BLENNY.
(Natural size.)

Spiny Eels

The so-called spiny eels of the Oriental region and West Africa form a family (*Rhynchobdellidæ*) affording an interesting example of parallelism in development, since these spiny-finned eels are an exact analogue of the true soft-finned eels. They are characterized by the elongate eel-like form of the body; the long dorsal fin, of which the anterior portion consists of short isolated spines; and the absence both of pelvic fins and of a papilla in the neighborhood of the vent. The gill opening forms a slit on the side of the head; four gills are contained in the gill chamber, and there are no false gills. An elongated movable

appendage forms the termination of the muzzle, and although the lower jaw is long, it has but little power of motion. As an especial peculiarity of these fishes, we may notice that in the skeleton there is no connection between the pectoral girdle and the skull. The air bladder is present. The species (*Mastacembelus armatus*), shown in the upper figure of the accompanying illustration, is one of the Indian representatives of a genus characterized by the smooth under surface of the appendage of the snout, and the presence of a preorbital spine. The members of this genus have a geographical distribution, coextensive with that of the family, being found in the brackish and fresh waters of West Africa, India, Ceylon, Burma, and the Malayan region. On the other hand, the genus *Rhynchobdella*, characterized by the striation of the lower surface of the nasal appendage, and the lack of a spine in



INDIAN SPINY EEL.
(One-third natural size.)

BAIKAL OIL FISH.
(One-half natural size.)

front of the eye, is confined to India and Burma, where it is represented by *R. aculeata*, which grows to a length of about fifteen inches, and is found in the deltas of all the larger rivers, generally preferring muddy pools. The figured species is, however, of larger size, reaching a couple of feet in length. The flesh of all the spiny eels is stated to be of excellent quality for the table.

Oil Fish

The fish represented in the lower portion of the above illustration, known as the Baikal oil fish (*Comephorus baikalensis*), is the only representative of a genus in regard to the systematic position of which there is considerable doubt; Dr. Günther regarding it as indicating a distinct family which he at one time placed in the neighborhood of the oblique-spined blenny, and afterward near the flying gurnards. In this fish the body is elongate and naked, the head

large with a produced muzzle, medium-sized lateral eyes, and small teeth. There are two dorsal fins, of which the first is much shorter than the second, which is similar to the anal; the pelvic fins are wanting, and there is no papilla near the vent. The gill opening is wide; there are four gills, and no air bladder. The skeleton is very soft, and the elements of the gill cover are not distinctly differentiated. In color this strange fish is uniformly greenish, and its pectoral fins are remarkable for their large size. While the oil fish presents some resemblance to the dragonets, it differs by the compressed body, the large, broad-snouted head, the elongation of many of the rays of the second dorsal fin, the large pectorals, the absence of pelvic fins, and the forked tail. So far as present information goes, the oil fish is confined to Lake Baikal, where in winter it retires to the greatest depths, but approaches the shore in the warmer months. Swimming with remarkable speed, it is enabled by the length of its pectorals to take considerable leaps above the surface of the water, and thus approaches the flying fish. During stormy weather great numbers of these fishes are frequently stranded, when they are collected by the natives for the purpose of extracting the oil from them.

Barracudas, Atherines, and Gray Mullets — Families *Sphyrænidæ*, *Atherinidæ*, and *Mugilidæ*

Following Dr. Günther's classification, these three families form a sectional group differing from those we have been considering by the position of the pelvic fins which are abdominal, and have one spine and five soft rays. The two dorsal fins are situated more or less remote from one another, the first being either short, like the second, or composed of weak spines.

Barracuda Pikes

The large and ferocious fishes commonly known as barracudas (*Sphyræna*), of which a species (*S. vulgaris*) is shown in the upper figure of the illustration on p. 2748, are the sole existing representatives of the first family, which is distinguished by the elongated and subcylindrical form of the body, the large cutting teeth, the continuous lateral line, and the presence of only twenty-four vertebræ in the backbone. The scales are small and cycloidal; the cleft of the mouth is wide; and the medium-sized eyes have a lateral position. Represented by something less than a score of species, barracudas are distributed over all temperate and tropical seas, but generally prefer the neighborhood of the coast of the open ocean. They are all carnivorous and fierce in their disposition, and since they frequently grow to six or eight feet in length, they are as much or even more dreaded by bathers in seas where they are more common than sharks. They are extensively caught for food, but in some instances, from their having fed on poisonous kinds of fish, their own flesh becomes impregnated with the venom. Moseley writes that "there is a great fishery at the Cape, of a fish called snook, a kind of barracuda, which is salted and dried, and sent mainly to Mauritius for sale. The snook boats were always to be seen about in the bay. The fish are caught with a hook and line while the boat is in motion. The fishermen are especially careful not to get bitten by the fish as they haul them in, wounds

caused by their bite being said to fester in a violent manner, as if inflamed." Fossil barracudas occur in the middle Eocene of Monte Bolca; while in the Cretaceous rocks of the Lebanon and Brazil the family is represented by the extinct genus *Cladocyclus*.

Sand Smelts

The second family of the group under consideration is typically represented by the so-called sand smelts; one of the two British species (*Atherina hepsetus*) being shown in the left figure of our illustration. As a family, the *Atherinidæ* are distinguished from the barracudas by the indistinct lateral line; the feeble or moderately-developed dentition, and by the number of



SAND SMELT AND CUVIER'S SQUARE TAIL.
(One-half natural size.)

vertebræ being usually in excess of twenty-four. The body is more or less elongate, with but slight compression. In the sand smelts the scales are smooth and cycloid, and the teeth minute; the first dorsal fin is short and completely separate from the second; and the muzzle is blunt, with the cleft of the mouth straight, oblique, and extending at least as far back as the line of the border of the eye. These fish derive their popular title from their resemblance to the true smelts, from which they may be distinguished at a glance by the small spinous first dorsal fin. While the majority are coast fishes, associating in large shoals, others are fresh-water, although these also retain the same habit. The genus has a wide

distribution in temperate and tropical seas, some of the species ranging from Eastern Africa to India. Atherines are very abundant in the Mediterranean, where the fry cling together for some time after hatching in enormous masses. Montagu writes that these fish are caught in great abundance on the south coast of Devonshire "in the creeks and estuaries, but never in rivers above the flow of the tide; and they appear to continue near shore through the months from autumn to spring, being caught for the table more or less during the whole of that time, but are greatly superior in spring, when the males are full of milt as the females are of roe." The British species seldom exceed six inches in length, and, like the other members of the genus, are marked by a broad silvery stripe along each side of the body. On the coasts and in the fresh waters of Australia, the sand smelts are represented by *Atherinichthys*, in which the muzzle is longer, and the cleft of the mouth usually shorter.

Square Tail

The curious Mediterranean and Atlantic fish known as Cuvier's square tail (*Tetragonurus cuvieri*), shown on the right side of our illustration, is the sole member of a genus characterized by the somewhat elongate



COMMON GRAY MULLET.
(One-sixth natural size.)

body being covered with strongly-keeled and striated scales; and by the first dorsal fin being composed of a number of short spines, and continuing to the second. The elevated lower jaw has a convex upper border, bearing a single series of rather small compressed and triangular teeth. Of the habits of this scarce fish nothing definite seems to be known; although in the young state it is found in company with floating jellyfish. At a later period of its existence it probably descends to a considerable depth during the day, and comes to the surface only at night. It grows to a foot and a half in length.

Gray Mullets

From the two preceding families the gray mullets, which constitute the third family of the group under consideration, may be distinguished by the total absence of a lateral line, the presence of only four stiff spines in the first dorsal fin, and the limitation of the number of vertebræ in the skeleton

to twenty-four. The more or less elongate and somewhat compressed body is covered with cycloid or slightly ctenoid scales of moderate size; the cleft of the mouth is small or medium; the teeth are feeble or wanting; the lateral eye is of moderate size, and the gill opening wide. In some species there may be a fatty lid to the eye. The gray mullets (*Mugil*), of which there is a very large number of species, are distributed over all temperate and tropical coast regions, frequenting brackish-water estuaries, and in some cases ascending rivers for considerable distances. Feeding chiefly upon the animals and organic matter found in sand and mud, these fishes have a special straining apparatus in the pharynx for the purpose of preventing objects of too large size from entering the stomach, or foreign substances getting into the gill chamber. It will be unnecessary to describe the structure of this apparatus here; but it may be mentioned that after triturating a mouthful of sand or mud between the pharyngeal bones, in order to extract such nutriment as it may contain, the gray mullets reject the mineral part of it. Another peculiarity is to be found in the structure of the œsophagus and stomach, the former being lined with long thread-like papillæ, while the latter has its second portion furnished with muscular walls like the gizzard of a bird, although it is not divided into two lateral halves. A fossil species of gray mullet has been described from the upper Eocene of Provence, and an extinct genus from the Cretaceous. Our figure represents the common gray mullet (*M. capito*), one of several species frequenting the British coasts. Although this mullet only grows to a weight of about four pounds, some of the foreign species may scale three times as much. This mullet has been kept in a fresh-water pond, where it seemed to thrive better than in the sea. The flesh of all the gray mullets is of good quality, but bears no comparison to that of their red namesakes.

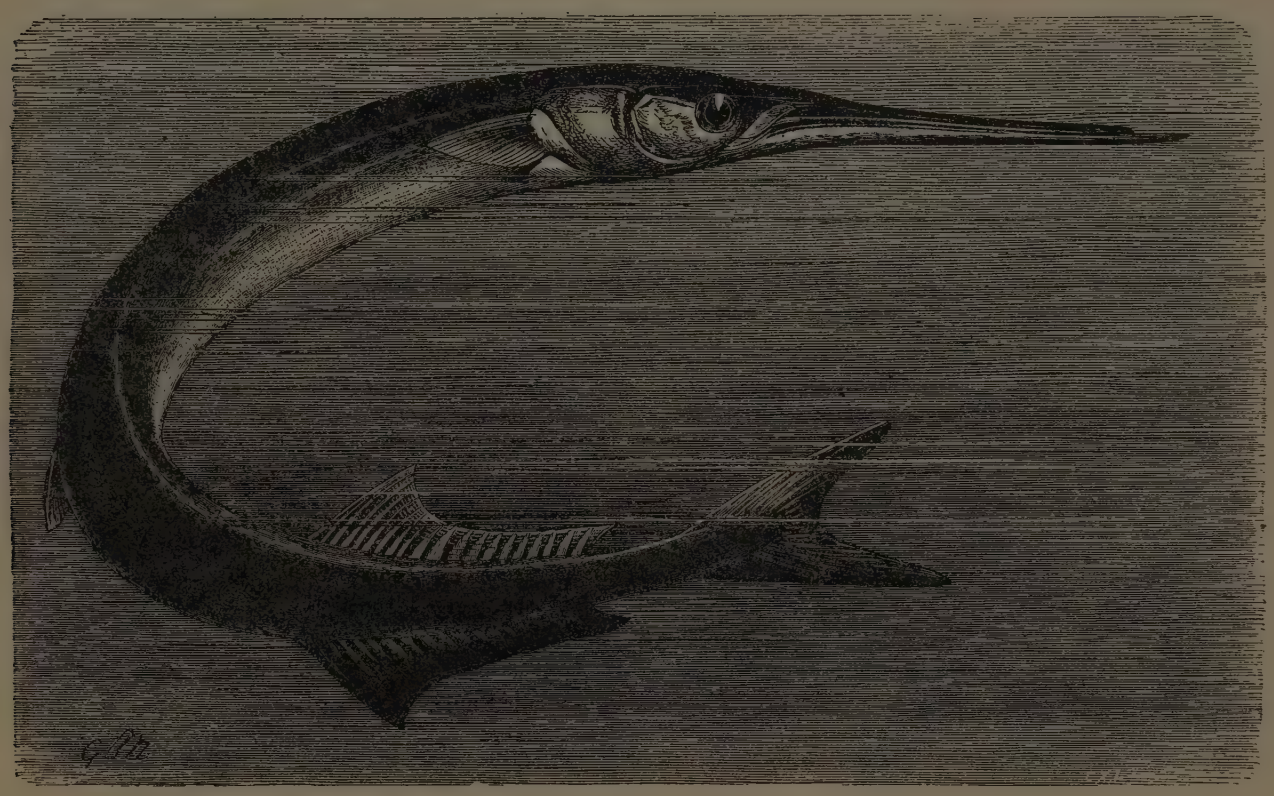
Gar Pike and Flying Fish — Family *Scombresocidæ*

In this place may be noticed a family in regard to the serial position of which there is some difference of opinion, Dr. Günther placing it among the tube-bladdered fishes, while Professor Cope considers that its true position is here. The inclusion of the group among the tube-bladdered fishes utterly spoils the definition of that suborder, since in those members of the present family provided with an air bladder that organ lacks a duct. It is true that the fins of the flying fishes and their allies are less spiny than those of the more typical representatives of the suborder under consideration, but, as we have seen, this characteristic is one of but slight morphological value. Agreeing with the preceding section in the abdominal position of the pelvic fins, these fishes differ from those yet described, with the exception of certain perches, in the union of the lower pharyngeal bones; while they are further characterized by the absence of a spinal dorsal fin, and the deeply-forked caudal. The single dorsal is situated opposite to the anal fin in the caudal region, the air bladder is generally present, the false gills are hidden and glandular, and the simple stomach merely forms a dilatation of the intestinal tract. Although the majority of the members of this family are marine, some being pelagic, a few have

taken to a fresh-water existence; and while many of the latter are viviparous, the whole of the others deposit eggs in the usual manner. Distributed over all the temperate and tropical seas, these fish are strictly carnivorous in their habits. Geologically, the family is a comparatively ancient one, the gar pike being represented by an extinct species in the Sicilian Miocene, and by an allied extinct genus in the Eocene of Monte Bolca, while a fish nearly allied to the living flying fishes occurs in the Cretaceous rocks of the Lebanon.

Gar Pike

In North America it appears that the name "gar pike" is applied indifferently to a member of the present family, and to the very distinct fish also known as the bony pike; but in scientific nomenclature it will be better to confine the term to the members of the present genus. Gar pikes are represented by nearly fifty species from temperate and tropical seas, among which the



GAR PIKE.
(One-sixth natural size.)

figured one (*Belone vulgaris*) is common on the British coasts, likewise ranging over the whole of the seas of Northern Europe. As a genus, these fishes are easily recognized by the production of the jaws into a long slender beak, formed in the upper one exclusively by the premaxillary bones; while they are further characterized by the whole of the rays of the dorsal and anal fins being connected by membrane. The beak is, however, only developed in the adult, very young specimens having the jaws of normal form; and it is not a little remarkable that during their development the lower jaw becomes for a time much longer than the upper one. Both jaws are beset with a number of rugosities, and likewise with a series of long, conical teeth placed at considerable intervals. A peculiarity of these fish is to be found in the green color of their bones. Whereas the British species does not exceed a couple of feet in length, some of the foreign representatives of the genus may

grow to as much as five feet. Dr. Günther writes that, skimming along the surface of the water, the gar pike seize with their "long jaws small fish, as a bird would seize them with its beak; but their gullet is narrow, so that they can swallow small fish only. They swim with an undulating motion of the body; but although they are in constant activity, their progress through the water is much slower than that of the mackerels, the shoals of which sometimes appear simultaneously with them on our coasts." Frequently they may be seen leaping out of the water over small floating objects in sportive play, and when struck by the hook throw themselves above the surface in violent contortions. The saury or skipper (*Scombresox saurus*) is the British representative of a much smaller genus, differing from the gar pikes by the minute size of the teeth, and likewise by the presence of a number of small finlets behind the dorsal and anal fins. On the other hand, the half beaks (*Hemirhamphus*), some of which inhabit fresh water, have the lower jaw larger than the upper throughout life.

Flying Fish

Perhaps few sights are more pleasing during a long sea voyage in an ocean steamer than to stand in the bows and to watch the flying fish rising—sometimes singly, but more frequently in larger or smaller shoals—from beneath the vessel to take their beautiful flight over the crest of the waves, till they once more disappear from view beneath the deep blue waters. Represented by more than forty species from tropical and subtropical seas, the flying fishes, of which the common species (*Exocœtus evolans*) is shown in the illustration on p. 2682, form a genus which may be at once recognized by the great length of the pectoral fins. They are further characterized by the blunt and short-jawed head, and the moderately long oblong body invested in a coat of rather large-sized scales; the teeth, when present at all, being minute or rudimental. The ordinary length of a flying fish is from ten inches to a foot, although specimens are occasionally met with half as long again; and whereas the common form ranges round the world, the distribution of some other species is extremely restricted, one being recorded only from the seas on the Pacific side of the Isthmus of Panama. The species differ considerably in the length of the pectoral fins; those in which they reach to the tail fin being capable of taking the longest flights, whereas in some others they do not extend beyond the anal. Associating in shoals, which are sometimes of immense size, all these fish are pelagic in their habits, and all are capable of taking the skimming flight from which they derive their name. That these fish take their flights primarily to escape from their enemies may be regarded as certain; and it is equally well ascertained that the continuance of the flight is due to the original impetus of the leap from the water, and is not prolonged by any flapping of the fins. From my own observations I am, however, of opinion that the pectoral fins are vibrated rapidly on first leaving the water for a few seconds, doubtless from a continuation of the swimming motion while in the water, after which they become entirely motionless. During flight, the color of these fins may appear either white or brown, when seen from above, according to the incidence of the light. So far as I have seen, flying fish are unable to change the direction of their course to any marked extent; but on this point, as will be seen from the two following accounts, there is some difference of opinion among observers. The first of these two accounts is

abridged by Dr. Günther from one published by Dr. Möbias, and runs as follows: "Flying fish are more frequently observed in rough weather and in a disturbed sea than during calms; they dart out of the water when pursued by their enemies, or frightened by an approaching vessel, but frequently also without any apparent cause, as is also observed in many other fishes; and they rise without any regard to the direction of the wind or waves. The fins are kept quietly distended, without any motion, except an occasional vibration caused by the air whenever the surface of the wing is parallel with the course of the wind. Their flight is rapid, but gradually decreasing in velocity, greatly exceeding that of a ship going ten miles an hour, and extending to a distance of five hundred feet. Generally, it is longer when the fish fly against than with, or at angle to the wind. Any vertical or horizontal deviation from a straight line is not caused at the will of the fish, but by currents of the air; the fish retaining a horizontally straight course when flying with or against the wind, but being carried to one side whenever the direction of the latter is at an angle to that of their flight. It may, however, happen that in the course of its flight a fish may dip its tail in the crest of a wave, thus changing its direction to the left or right. In calm weather the line of flight is always also vertically straight, or rather parabolic, like the course of a projectile, but in a rough sea, when the fish are flying against the course of the waves, it may become undulating. In such instances the flying fish frequently overtop each wave, being carried over by the pressure of the disturbed air. Flying fish often fall on board vessels, but this never happens during a calm, or from the lee side, always taking place in a breeze and from the weather side. In the daytime they avoid a ship, flying away from it; but, during the night, when they are unable to see, they frequently fly against the weatherboard, where they are caught by the current of air, and may be thus carried to a height of some twenty feet above the surface of the water." In the second account, which was published many years ago in *Land and Water*, the author writes that in calm weather flying fish "are capable of clearing three hundred yards. Their flight is frequently extended to double the distance by simply skimming the surface, as a swallow does a pool, and without disappearing. I have observed that they never touch the surface more than twice consecutively, though they may resume their flight after a period of complete immersion; while still in the air, they readily change their course to right angles with their first line of flight, or even completely reverse it toward the point from which they originally started. I have watched them for hours through a powerful double glass, as they rose from either side of the bows of the ship, and noticed that the pectoral fins are moved with a slight but very rapid quivering motion, which, I have no doubt, assists to sustain them in the air. In rough weather the flight of the flying fish is more rapid, much higher, and of shorter duration than when light winds prevail." This account confirms my own observations as to there being a vibratory motion of the pectoral fins when first leaving the water, although the writer is probably incorrect in his supposition that this assists the flight.

Sticklebacks, Flutemouths, and Trumpet Fish — Families *Gastrosteidæ*, *Aulostomatidæ*, and *Centriscidæ*

Although the third of the above-named families is regarded by Dr. Günther as forming a group apart, we may follow Day in placing the whole three in a single section, characterized by the spinous dorsal fin, when present, being either short or formed of isolated spines, and by the generally abdominal position of the pelvic fins, which in some instances are imperfectly developed.

Sticklebacks

Familiar to every home-born Englishman as the fish upon which, in common with minnows, he made his first experiment in angling with the aid of a bit of twine, a bent pin, and a worm, the sticklebacks have the honor not only of representing a geuus (*Gastrosteus*), but likewise a family by themselves. Taking their name from the presence of a variable number of isolated spines in advance of the soft dorsal fin, sticklebacks have the body more or less elongated and compressed, the cleft of the mouth oblique, and the teeth villiform. The gill cover is unarmed, and the cheek covered by the infraorbital bone; and in place of scales there are generally large plates along the sides of the body. The pelvic fins, although abdominal in position, are connected with the pectoral girdle by means of the pelvic bones, and consist of but one spine and a single ray; and there are but three branchiostegal rays. Confined to the Temperate and Arctic zones of the Northern Hemisphere, where they are represented by some half-score species of small bodily size, sticklebacks are mainly fresh-water fishes, although the sea stickleback (*G. spinachia*) is a marine or brackish-water form, and all the rest can live as well in salt as in fresh water. The British fresh-water representatives of the genus are distinguished by the number of the dorsal spines, and are known as the three-spined (*G. aculeatus*), four-spined (*G. spinulosus*), and nine-spined sticklebacks (*G. pungitius*); while in the United States *G. novæboracensis* is the most familiar kind. The three-spined stickleback is a singularly variable species, the plates which are present on the sides of the body in some specimens, being wanting in others; the unprotected condition being especially common in the race from Central Europe. Very different in appearance from the others is the fifteen-spined, or sea stickleback, in which the body is very long and thin; this species ranging as far north as Norway and the Baltic. It has recently been ascertained that all the individuals of this stickleback die within a year of their birth; so that we have here a second example of an annual vertebrate, the first being the one mentioned on p. 2759.

Sticklebacks are extremely pugnacious, and at the same time highly voracious fishes, the males engaging in fierce conflicts with one another; while both sexes consume a vast quantity of the fry of other fish, and are, therefore, most objectionable denizens of preserved waters. It is not indeed that a single stickleback can do a very great deal of harm, but the mischief results from the enormous numbers of these little marauders. As an instance of this, we may once more quote the well-known statement of Pennant, that a man employed by a Linconshire farmer to rid a stream of sticklebacks, for a considerable time made a dollar a day by selling his catch at the rate of a penny a bushel. In fighting, the males make full use

of the formidable spines on the back, with which they have been seen to rip open the body of an antagonist. The most interesting trait in the economy of sticklebacks, is, however, undoubtedly the nest-building habit of many of the species. In the sea stickleback the nest is composed of a mass of pendent seaweeds, bound together by a silk-like thread into a pear-shaped form, in the centre of which are deposited the eggs. Such a nest has been known to be guarded for a period of upward of three weeks by the male parent fish; and when it sustained any damage, by which the eggs were exposed to view, the watchful guardian set about repairing the mischief with the greatest dispatch and energy, thrusting its nose deep into the structure, and pushing and pulling the materials till all was once more sound. The following ac-



GROUP OF STICKLEBACKS.
(Natural size.)
Sea stickleback (upper figure); Nine-spined stickleback (middle figure); and Three-spined stickleback (lower figure).

count of the nesting of the three-spined stickleback in an aquarium was forwarded by a correspondent to Frank Buckland. On this occasion the male "selected a spot nearly in the centre of the trough, and busily set to work to make a collection of delicate fibrous materials, placed on the ground, and matted into an irregularly circular mass, somewhat depressed, and upward of an inch in diameter, the top being covered with similar materials, and having in the centre a rather large hole. His work was commenced at noonday, and was completed, and the eggs deposited by half-past six in the afternoon. Nothing could exceed the attention from this time

evinced by the male fish. He kept constant watch over the nest, every now and then shaking up the materials and dragging out the eggs, and then pushing them into their receptacle again, and tucking them up with his snout, arranging the whole to his mind, and again and again adjusting it till he was satisfied; after which he hung or hovered over the surface of the nest, his head close to the orifice, the body inclined upward at an angle of about 45°, fanning it with the pectoral fins, aided by a side motion of the tail. This curious manœuvre was apparently for the purpose of ventilating the spawn; at least by this means a current of water was made to set in toward the nest, as was evident by the agitation of particles of matter attached to it. This fanning or ventilation was frequently repeated every day till the young were hatched; and sometimes the fish would dive head foremost into his nursery and bring out a mouthful of sand, which he would carry for some distance and discharge with a puff. At the end of a month the young ones were first perceived. The nest was built on the twenty-third of April, the young appearing first on May 21. Unremitting as had been the attention of this exemplary parent up to the time of the hatching of the eggs, he now redoubled his assiduity. He never left the spot either by day or night; and during the daytime he guarded it most pertinaciously, allowing nothing to approach. . . . The fry were at first so minute and transparent that they were scarcely perceptible, and it was only by a slight fluttering motion their position could be occasionally discovered; otherwise it was impossible to detect them.''

Flutemouths

Although the name of pipefishes is frequently applied to the members of the second family of the group under consideration, it is better to restrict that term to the *Syngnathidæ* (described in the sequel), and take that of flutemouths for those to be now noticed. As a family the flutemouths are readily distinguished from the sticklebacks by the production of the bones of the muzzle into a long tube, terminated by a small mouth; and likewise by the pelvic fins consisting of six soft rays. The greatly-elongated body is either covered with very small scales, or naked; the teeth are small; the first dorsal, if present, is formed of small isolated spines; the soft dorsal and anal are of moderate length; the pelvic fins consist of six rays, without any spine, and are separated from the pubic bones, which remain attached to the pectoral arch; and there are five branchiostegal rays. The air bladder is large, and the vertebræ are very numerous, those in the anterior part of the column being fused into a continuous tube, as in the flying gurnards. These fishes, which may be regarded as gigantic and highly-specialized marine sticklebacks, frequent the coasts of the tropical and subtropical portions of the Atlantic, Indian, and Pacific Oceans, some of them growing to from four to six feet in length. In the genus *Fistularia*, the body is naked, the forked caudal fin has one or two of its middle rays produced into a long whip-like filament, and there are no isolated spines to the dorsal fin. The species are confined to the tropical Atlantic and Indian Oceans. On the other hand, in the typical genus *Aulostoma* the body is covered with small scales, the caudal fin squared, and without filaments, while the back carries a series of small isolated spines, and the teeth are rudimentary. In this genus the species inhabit the Atlantic; but the third genus (*Auliscops*) is represented by a single form from the Pacific coast of this continent, distinguished by the naked body, the thoracic position of the pelvic fins, and the presence of

numerous spines in front of the dorsal fin. Day states that he found the Indian species of *Fistularia*, which is common in Madras, frequenting the most muddy localities.

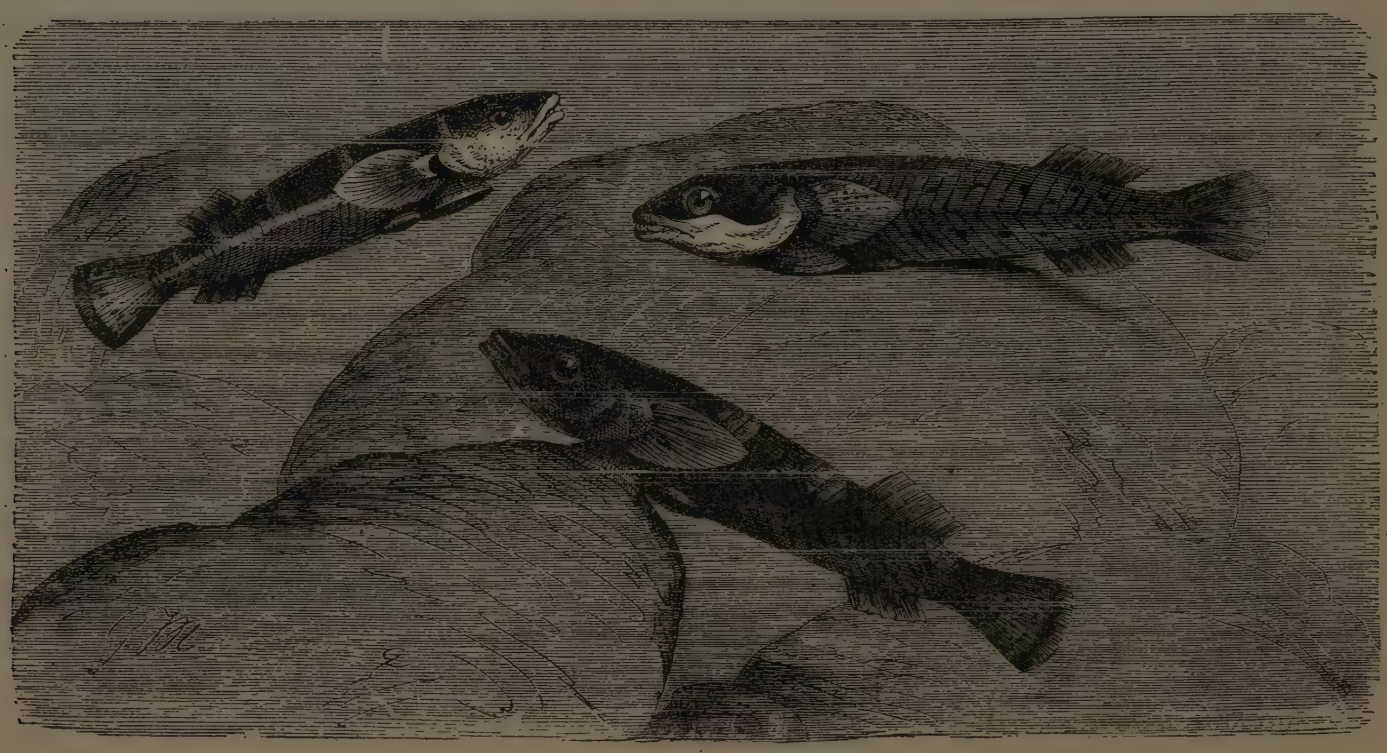
Trumpet Fishes, etc.

While agreeing with the flutemouths in the production of the muzzle into a tubular beak, the two genera of fishes constituting the family *Centriscidæ* differ by the imperfect development of the pelvic fins, which are truly abdominal in position. They have two dorsal fins, of which the spinous one is short, while the soft one is similar to the anal. Teeth are wanting. The family is distributed over the Atlantic, Mediterranean, and the Indo-Pacific, the common trumpet or bellows fish (*Centriscus scolopax*) occasionally making its appearance on the south coast of England, while it is also known from such a distant region as Tasmania. It belongs to a genus characterized by the oblong or elevated and compressed body being covered by small rough scales, with some bony strips on the back and under surface, the absence of a lateral line, and the length of the spines of the first dorsal fin. The second genus, *Amphisile*, differs by the elongate form of the compressed body, which is covered on the back with a cuirass of bony plates, behind which are the two dorsal fins. This genus is confined to the Indo-Pacific; and in the Indian *A. scutata* the dorsal armor terminates behind in a long spine, close beneath which are the three spines of the first dorsal fin, followed by the second dorsal, the caudal appearing on the lower surface of the body just behind the anal. Dr. Günther writes that in these tortoise fishes, as they may be called, the "body is so thin that it has the appearance of being artificially compressed between two sheets of paper; it is semi-transparent, especially in the region of the air bladder. The structure of the vertebral column is extremely singular, and unique among Acanthopterygians. The trunk portion is more than four times as long as the caudal, nevertheless it is composed of only six vertebræ, while the latter consists of fourteen." The trunk vertebræ are extremely slender, the third alone being nearly as long as the whole caudal portion; while in the latter all the vertebræ are very short. In a fossil state the tortoise fishes are represented in the middle Eocene of Monte Bolca; and it may be mentioned here that in the preceding family the genera *Fistularia* and *Aulostoma* occur not only in those deposits, but likewise in the lower Eocene of Switzerland; and *Auliscops* has been recorded from the Eocene of Sumatra, and two extinct generic types have been described from the Monte Bolca beds.

The Sucker Fishes — Family *GOBIOESOCIDÆ*

The small fish (*Lepadogaster bimaculatus*) of which three examples are shown in the annexed illustration, is one of three British representatives of a genus belonging to a small family which constitutes a sectional group by itself. Long confounded with the lumpsuckers, which they resemble in having an adhesive disc on the under surface of the body, the sucker fish differ from that group, not only in the structure of the disc, but likewise in several other respects. They have no spinous dorsal fin; the soft dorsal and anal are short or of medium length, and situated far

back, at the root of the tail; the pelvic fins are almost jugal in position, and have the adhesive disc placed between them, while the body is covered with a naked skin. Whereas in the lumpsuckers the pelvic fins are close together, and actually form the base of the sucking disc, in the present family they are widely separated from each other, and only enter into the composition of a portion of the margin of the adhesive apparatus, which is completed by a cartilaginous expansion of the bones of the pectoral girdle. In size the ovid disc is relatively large, its length being sometimes as much as one-third that of the whole fish, and it is divided into an anterior and a posterior moiety, of which the second may or may not have a free front margin. All these fishes are littoral forms of small size, ranging over both temperate zones, where they are more numerous than in the tropics. Among the numerous genera we can only mention the typical *Gobioesox*, from the West Indies and Pacific



TWO-SPOTTED SUCKER FISH.
(Natural size.)

coast of South America, distinguished by the absence of a front free margin to the posterior division of the sucker, and the presence of incisor-like teeth at least in the lower jaw; and the European *Lepadogaster*, in which the hinder half of the sucker has an anterior free margin, and the teeth are small and fine. The British species, although variable in this respect, are very prettily colored; the figured one being generally carmine red above, and pale flesh color below, with a light patch between the eyes, and two more or less distinct spots on the sides. It has been obtained adhering to stones and shells in deep water off Torquay. Montagu writes that when placed in a vessel of sea water these little fish "always adhere to the sides of the glass by the apparatus termed the sucker, and frequently remain fixed till they die; and even after death the power of adhesion continues. The wet finger being applied to the part, the fish becomes suspended; when alive, they instantly attach themselves to the hand if taken out of the water."

The Serpent Heads — Family *Ophiocephalidæ*

Mainly characteristic of the Oriental region, although also represented in Africa, the fresh-water fishes known as serpent heads are interesting not only on account of their structure, but likewise from their peculiar habits. They form a single family, constituting a sectional group by itself, and represented by two genera, in one of which (*Ophiocephalus*) pelvic fins are present, while in the second (*Channa*) they are wanting. As a family, the serpent heads are characterized as follows: The body is elongate and covered with medium-sized scales; all the fins are devoid of spines, the anal and single dorsal being long and low; and there is an additional cavity above the proper gill chamber, although this is not furnished with supplemental gills. The depressed head is covered with somewhat plate-like scales, and



STRIATED SERPENT HEAD.
(One-ninth natural size.)

has the eyes lateral and the gill openings wide; each gill chamber containing four gills, while teeth are present on the jaws, palatines, and vomer. If present, the pelvic fins are thoracic in position, and composed of six rays. The lateral line is sharply curved or almost interrupted, and an air bladder is present. Of the typical genus there are some thirty existing species, having a distribution coextensive with that of the family, and in Asia ranging over Baluchistan, Afghanistan, India, Ceylon, Burma, China, Siam, and the Malay Archipelago; the figured species (*O. striatus*) being common to such distant localities as India and the Philippines, and at times reaching as much as a yard in length. The second genus, *Channa*, is represented only by a single species from Ceylon and China. In a fossil state these fishes have been identified from the Pliocene rocks of the Siwalik hills in North-eastern India.

In India the serpent heads are found in rivers, ponds, tanks, and swamps, many of them seeming to prefer stagnant to running waters. Day writes that

these fishes "having hollow cavities in their heads, and an amphibious mode of respiration, are able to exist for lengthened periods out of their native element, and can travel some distance over the ground, especially when it is moist. They are able to progress in a serpentine manner, chiefly by means of their pectoral and caudal fins, first one of the former being advanced and then the other. These fishes appear to be monogamous, some breeding in grassy swamps or the edges of tanks, some in wells or stone-margined receptacles for water, and others again in holes in river banks. The varieties which live in tanks and swamps keep much to the shallow and grassy edges. Among the fish which I myself saw exhumed from the mud of a dried-up tank were some *Ophiocephali;* they are also recorded by the natives of India as descending with downpours of rain." When living in muddy water they rise to the surface from time to time to take in atmospheric air, and captive examples prevented from doing this have been known to die. During the time they are buried in hard mud it must be assumed that these fish become completely torpid and stop the respiratory function.

The Labyrinth-gilled Fishes — Families *Anabantidæ* and *Luciocephalidæ*

In the members of these two families of estuarine and fresh-water fishes, which constitute a sectional group by themselves, the apparatus for enabling them to exist for a considerable time out of the water is carried to a greater degree of complexity than in the last, and takes the form of a laminated accessory gill-like organ, situated in a chamber on each side of the head above the one containing the true gills. In these fishes the body is compressed, oblong, and elevated, with medium-sized ctenoid scales. The eyes are lateral, the gills four in number, the gill opening rather narrow, and false gills either rudimentary or wanting. The single dorsal fin, as well as the anal, has a variable number of spines; and the pelvic fins are thoracic in position. While in some cases the lateral line is interrupted, in others it is altogether wanting; and the air bladder may be either present or absent, but when developed it is generally very large, sometimes even extending into the tail. These fishes, which are of comparatively-small size, are confined to Southern Asia and South Africa, and are all capable of existing for a longer or shorter period out of their native element, when they oxygenate their blood directly from atmospheric air by means of the accessory gill-like organ. Whereas some are carnivorous, others are vegetable feeders; but all are capable of domestication, in which state they are subject to considerable variation, and several have been acclimatized in countries other than their own. The flesh of all of them is said to be eatable, and that of some is of excellent quality. On account of their brilliant coloration, and the curious habits of some of them, these fish have always attracted more than ordinary interest.

Climbing Perch

The fish to which the somewhat inappropriate name of climbing perch (*Anabas scandens*) has long been applied by Europeans in India is the sole representative of a genus characterized by the presence of teeth on the palate, and the serration of the free margins of the opercular and preorbital bones.

In form the body is compressed and oblong; the lateral line is interrupted; the single dorsal fin has its spinous portion much longer than the soft part, while in the anal fin the spines are less numerous than those on the back. The caudal fin is rounded, and the scales are rather large. In length the climbing perch may reach at least eight and one-half inches, and in the adult state its general color is dark green, usually marked with dusky bands, which disappear soon after death. It frequents estau-



CLIMBING PERCH ON LAND
(One-half natural size.)

ries, rivers, and tanks, and is distributed over India, Ceylon, Burma, the Malay Archipelago, and the Philippine Islands. That this fish can travel long distances on land, where it drags itself along by hitching its pectoral fins round the stems of grass and other herbage, in the manner indicated in our illustration, is perfectly-well ascertained. With regard to its climbing powers some amount of incredulity has been expressed, but it is very noteworthy that its Malayan name (*undi-colli*) signifies tree climber, while nearly a thousand years ago certain Arab travelers were informed

of the existence in India of a fish that was in the habit of ascending cocoa-nut palms to drink their milk. Apparently the only definite record that we have of a European having witnessed such scansorial feats is from the pen of one Daldorf, who wrote that in the year 1791 he had taken one of these fishes from a moist cavity in the stem of a palmyra palm growing near a lake. He first observed it when already five feet from the ground, struggling to ascend higher, and suspending itself by its gill covers; and bending its tail to the left, it fixed its anal fin in the cavities of the bark, and sought by expanding its body to urge its way upward, and its march was only arrested by the hand with which he seized it. Although there is no reason to doubt this very detailed narrative, the circumstance that later observers in India have never seen the feat repeated would seem to indicate that it



PARADISE FISH AND TELESCOPE FISH.

is but seldom the fish takes to actual climbing. Regarding the habit of this fish, in common with the serpent heads, of burying itself in the mud of tanks, Sir J. E. Tennent writes that "in those portions of Ceylon where the country is flat, and small tanks are extremely numerous, the natives are accustomed, in the hot season, to dig in the mud for fish. Mr. Whiting inform me that, on two occasions, he was present accidentally when the villagers were so engaged, once at the tank of Malliativoe, within a few miles of Kottiar, near Trincomali, and again at a tank on the Vergel river. The clay was firm but moist, and as the men flung out lumps of it with a spade, it fell to pieces, disclosing fish from nine to twelve inches long, which were full grown and healthy, and jumped on the bank when exposed to the sunlight."

Paradise Fish

The Oriental region is the home of another allied genus of fishes (*Polyacanthus*) represented by several species, and differing from the climbing perch by the absence of teeth on the palate, and the smooth margins of the preorbital and opercular bones; the mouth being small and slightly protractile. The spinous part of the single dorsal fin is much longer than the soft portion, the anal being similar; the pelvic fins have one spine and five soft rays, some of which are usually elongated; and the caudal is rounded or pointed. The lateral line, which is never complete, may be wanting. These fishes inhabit fresh waters and estuaries along the coast of Southeastern Asia, but are seldom found any great distance inland. The pretty and brightly-colored paradise fish is an inhabitant of



THE GURAMI.
(One-fifteenth natural size.)

China and Cochin-China, and was long regarded as the representative of a distinct genus. It is, however, now known to be merely a domesticated variety of a species of *Polyacanthus*, although we are not aware that the normal form has hitherto been discovered. From our figure it will be seen that it differs from the ordinary members of the genus in the large and forked tail, and likewise in the great development of the soft rays of the dorsal and anal fins. Throughout China this fish is kept in confinement; and is even more suited to captivity than the goldfish, as it will breed in vessels of very small capacity. It is even stated to live in water strongly impregnated with acid, and its tenacity of life is very great. When kept in dark or muddy waters the color is generally a dull uniform brown; and it is only when living in clear water, exposed to the sunlight, that the golden hue and red transverse

bands make their appearance, these showing at an earlier period in the males than in the females.

Gurami

On account of the excellent quality and tastes of its flesh, mention must be made here of the gurami (*Osphromenus olfax*) as a well-known representative of a third genus belonging to this family. Agreeing with the members of the preceding genus in the absence of teeth on the palate, the smooth border to the preorbital and opercular, and the structure of the pelvic fins, these fishes differ by the smaller number of spines in the dorsal or anal fins, which are either fewer than the soft rays, or but very slightly exceed them. The body is moderately elevated and compressed; the small and oblique mouth is capable of a considerable degree of protrusion; and the first ray of the pelvic fins is elongated into a slender filament, the remainder being generally rudimentary. When present the lateral line is continuous; and there is always an air bladder. Distributed over the rivers of Southeastern Asia, these fishes are represented in India only by a small species (*O. nobilis*) of some four inches in length, inhabiting Northeastern Bengal and Assam. The gurami, which is a native of the rivers of China and the Malayan Archipelago, has, however, been introduced into several parts of India and has also been naturalized in the Mauritius, Cayenne, and Australia. It is easily recognized by its large size, great convexity of the profile of the under surface, and greenish-brown color, marked in the immature condition by four or five dark vertical bands. It attains a weight of fully twenty pounds, and, when kept in clean water, is stated to be the best flavored fresh-water fish in Southeastern Asia. As it is extremely tenacious of life, and likewise almost omnivorous in its diet, it is in every way very admirably adapted for transportation and acclimatization.

Fighting Fish

A fourth genus (*Betta*), distinguished by the short dorsal fin occupying the middle of the back, and without any pungent spine, the long anal, and the production of the outer ray of the five-rayed pelvic fins, must also be mentioned on account of its containing the so-called fighting fish (*B. pugnax*) which is bred by the Siamese for the sake of the sport afforded by its pugnacious propensities. Cantor writes that, "when the fish is in a state of quiet, its dull colors present nothing remarkable; but if two be brought together, or if one sees its own image in a looking-glass, the little creature becomes suddenly excited, the raised fin and the whole body shine with metallic colors of dazzling beauty, while the projected gill membrane, waving like a black frill round the throat, adds something of grotesqueness to the general appearance. In this state it makes repeated darts at its real or reflected antagonist. But both, when taken out of each other's sight, become instantly quiet. This description was drawn up in 1840 at Singapore, by a gentleman who had been presented with several by the King of Siam. They were kept in glasses of water, fed with larvæ of mosquitoes, and had thus lived for many months. The Siamese are as infatuated with the combats of these fish as the Malays are with their cockfights, staking on the issue considerable sums, and sometimes their own persons and families. The license to exhibit fish fights is farmed, and brings a considerable annual revenue to the King of Siam. The species abounds in the rivulets at the foot of the hills of Penang."

Pike Head

The small fish (*Luciocephalus pulcher*) from the fresh waters of the Malay Archipelago, shown in the accompanying illustration, is the sole representative of the second family of the labyrinth-gilled group, which differs from the first in the absence of spines from both the dorsal and anal fins. The species derives its name from the produced muzzle and general pike-like form of the head; and has its elongate body covered with moderate-sized scales, and traversed



PIKE HEAD.
(Natural size.)

by a continuous lateral line. The teeth are small, and the gill openings wide. The single spineless dorsal fin is very short and placed far back on the body; the pelvics consist of one spine and five rays, one of the latter being elongated; and the tail fin is rounded. There is no air bladder. Nothing is known with regard to the life history of this prettily marked fish.

UNICORN AND RIBBON FISH — Families *LOPHOTIDÆ* and *TRACHYPTERIDÆ*

Agreeing in their ribbon-shaped bodies, and also in the extension of the dorsal fin from the head to the end of the tail, the unicorn and ribbon fishes are thereby easily distinguished from all the preceding forms, although they differ so much from one another as to be entitled to form distinct families, each of which is regarded by Dr. Günther as representing a sectional group.

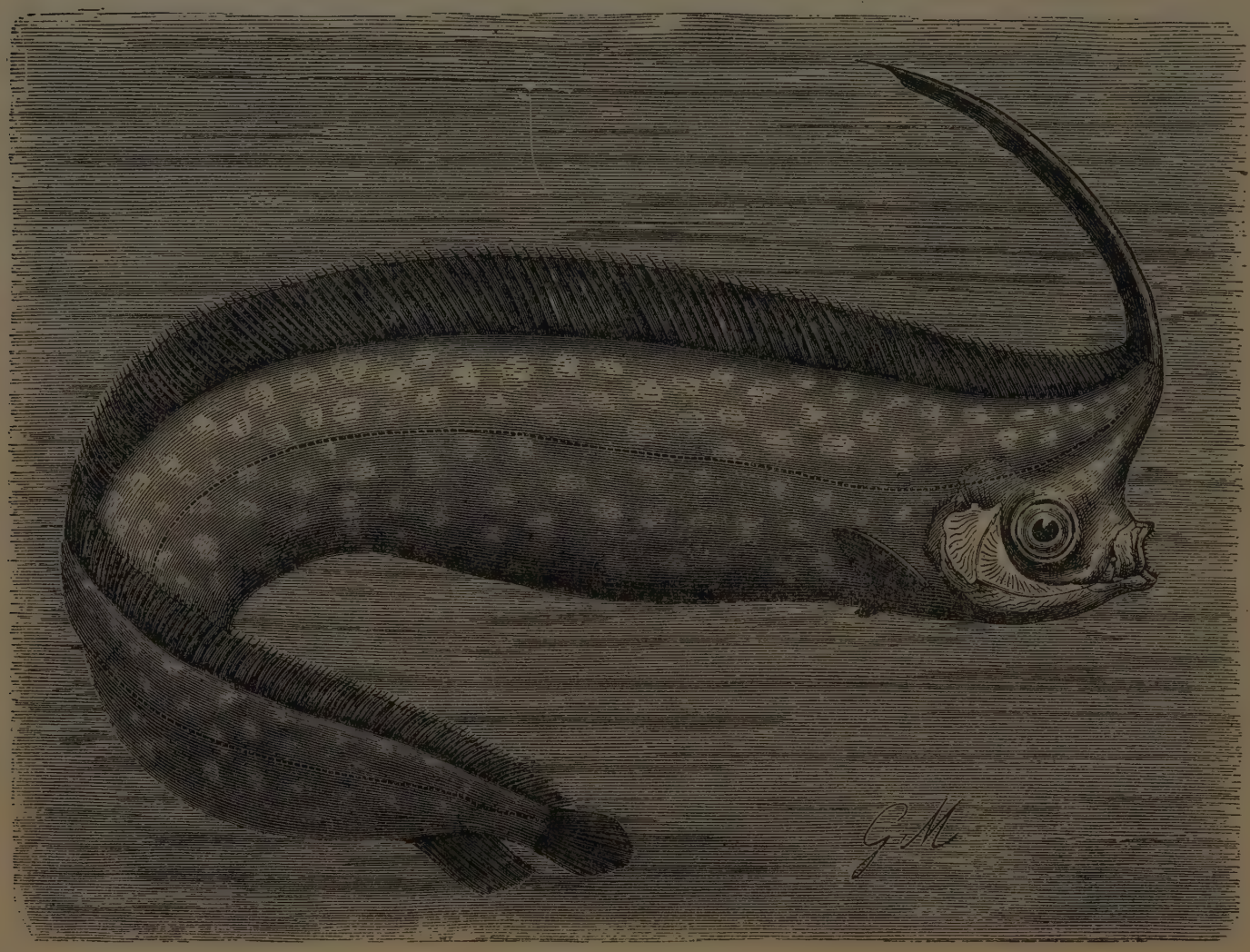
Unicorn Fish

The single representative of the first family (*Lophotes cepedianus*) differs from the whole of the members of the subclass hitherto described, in that the vent is situated at the hinder extremity of the body, close to the tail, with a small anal fin immediately behind it. The pelvic fins are very minute, and thoracic in position; the caudal is also small and rounded; the mouth is incapable of protrusion; teeth are present on the jaws, palatines, and vomers; and there is an air bladder. The most striking peculiarity about this strange fish is the elevation of the crown of the head into a high crest, surmounted by an exceedingly-long and recurved spine forming the commencement of the dorsal fin. The bones and

flesh are firm, the general color is silvery, with lighter spots, but the fins are rosy, and the total length is at least five feet. This fish, which has been taken in the Atlantic off Madeira, and also in the Sea of Japan, probably dwells at a considerable depth, although not so far down as the ribbon fishes. Its habits are unknown.

Ribbon Fishes

From the unicorn fish the members of this family may be distinguished by the absence of an anal fin, and by the caudal (which, as in our figure, is rarely preserved in the adult state) being either rudimental, or small and bent up above the axis of the body in a fan-like manner. The band-like



UNICORN FISH.
(One-tenth natural size.)

body, which may measure as much as fifteen or twenty feet in length, with a depth of a foot and a breadth of not more than an inch, terminates in a short and deep head, furnished with large lateral eyes, and a small mouth; the teeth being feebly developed. The high dorsal fin is composed of a very numerous series of rays, which are neither articulated nor branched, and has a detached portion on the crown of the head elevated into tall filaments,* and the thoracically-placed pelvic fins may consist either of several rays, or be reduced to a single long filament. Scales are wanting; and the numerous vertebræ as well as the other bones, are re-

*In our figure this part is represented as connected with the rest of the fin.

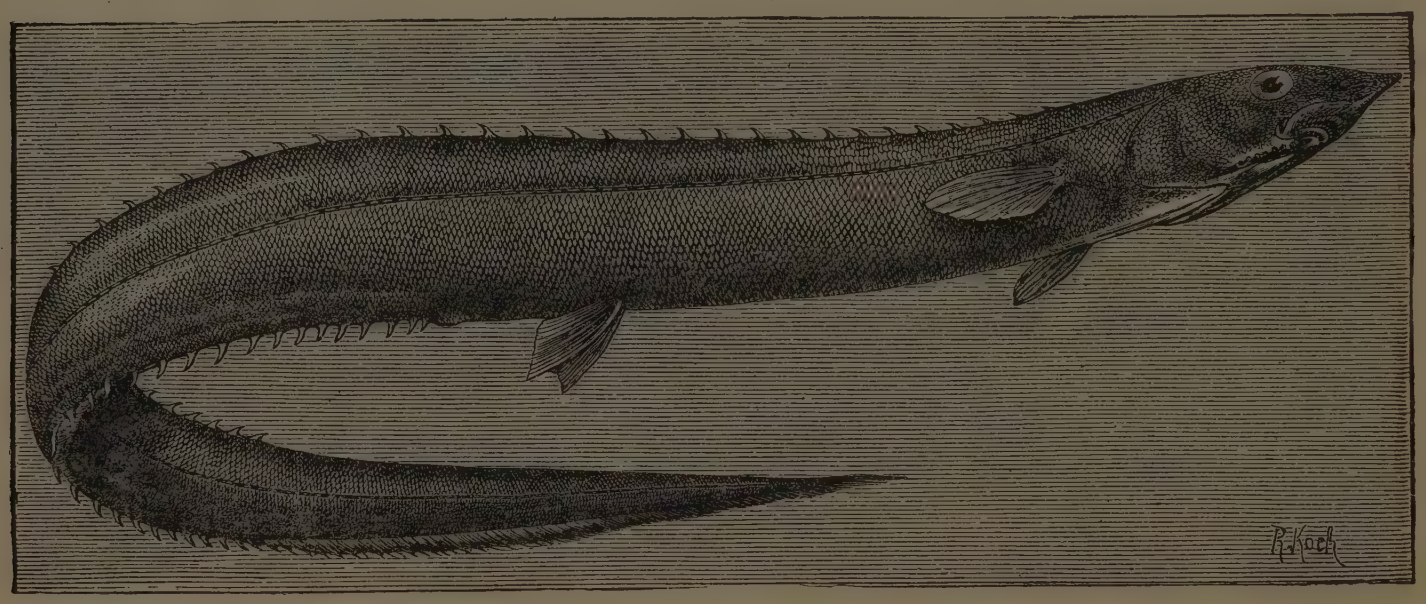
markable for their softness and loose structure; the flesh being likewise of a flabby consistence. The young, which are not unfrequently found at the surface of the ocean, are very unlike the adults, having the body more like that of an ordinary fish, but remarkable for the enormous development of the rays of the front part of the dorsal and pelvic fins, and in a minor degree those of the caudal likewise. The dorsal rays are, indeed, several times the length of the whole fish, and are furnished at intervals with barb-like dilatations. Most ribbon fish are silvery in color, with rosy fins. They are divided into three genera, of which *Trachypterus* has well-



BANKS'S RIBBON FISH.
(One-twelfth natural size.)

developed pectoral fins, while *Stylophorus* has the tail produced into an exceedingly long filament; *Regalecus* being distinguished by the reduction of the pelvic fins to a pair of long filaments with dilated extremities, and the small size or rudimentary condition of the caudal. Our figured example (*R. banksi*) belongs to the third genus, and has the body of considerable relative depth, but in a much smaller Indian form (*R. russelli*) the body is so slender as to have a rod-like appearance. Banks's ribbon fish appears to be only known from specimens cast ashore on the British coast, the first of these having been stranded at Whitby in January, 1759,

since which date only fifteen other examples were recorded up to 1878. All these fishes are, indeed, known almost entirely from examples found in a dead or dying condition on the surface of the ocean, or cast ashore by the waves. In this state the whole of their tissues are so disintegrated and broken that the body can scarcely be lifted whole from the water, and it is thus evident that ribbon fishes are inhabitants of the lower strata of the ocean, although at what precise level they live has not yet been ascertained. They are found in all seas, but are mostly of very rare occurrence on the surface, the single representative of the genus *Stylophorus* being only known by one example captured in the early part of this century near Cuba; while the same is the case with regard to Russell's ribbon fish from Madras. That the young are also deep-sea fishes is, as Dr. Günther remarks, perfectly evident



RISSO'S THORNBACK.
(One-half natural size.)

from their filamentous fins, which would be irretrievably damaged if their owners did not live at depths where the water is perfectly undisturbed. From the expansion of the extremities of the pelvic fins, Banks's ribbon fish has been named the oar fish; while from a supposed idea that it accompanied the shoals of those fishes, it has likewise been designated the king of the herrings. It has been suggested that large ribbon fish floating on the surface have given rise to many of the reports regarding the sea serpent; but, as Dr. Günther pertinently points out, such dead or dying creatures do not by any means accord with the active movements generally attributed to that mythical monster. Still, however, we believe that a stranded ribbon fish has been mistaken for a dead sea serpent.

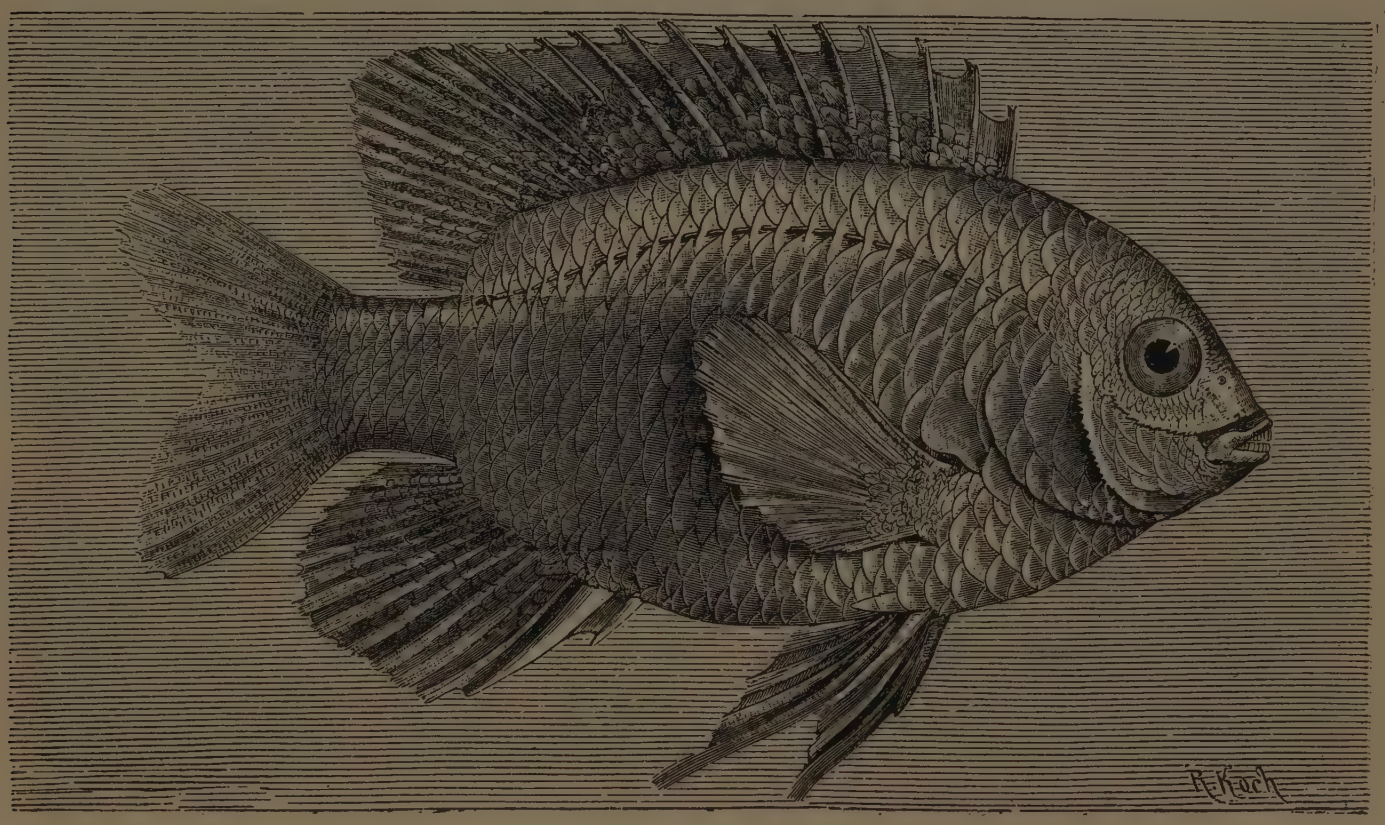
The Thornbacks — Family *NOTACANTHIDÆ*

The last family of the great division of spiny-finned fishes we have been considering in the foregoing paragraphs includes only the deep-sea fishes known as thornbacks, all of which are referred to the single genus *Notacanthus*. These fishes are

very abnormal forms, agreeing only with the more typical members of the suborder to which they are referred in the presence of spines in the median fins. Possessing an elongate and somewhat compressed body, covered with minute scales, they are specially characterized by having the dorsal fin composed of a series of low isolated spines, without any soft portion; while the anal is elongated, with a great number of spines; the pelvic fins being abdominal in position, and comprising more than five soft rays, in addition to several unarticulated ones. In the head the muzzle is prolonged in advance of the mouth; the moderate-sized eyes are lateral in position; and the teeth are small and weak. The six known species range from the Arctic Ocean to the Mediterranean, Atlantic, and South Pacific. All are deep-sea fishes, probably dwelling at depths of from a hundred to five hundred fathoms; although one specimen taken to the south of Yokahama during the voyage of the *Challenger* is stated to have come from a depth of nearly nineteen hundred fathoms.

The Wrasse-like Fishes — Families *Pomacentridæ*, *Labridæ*, *Chromididæ*, etc.

In almost all the families of spiny-finned fishes hitherto described the lower pharyngeal bones are completely separated from one another, whereas in the four families remaining for consideration these are united with one another. It has been



SILVER-DOTTED POMACENTRUS.
(Five-sixths natural size.)

considered that this difference was of sufficient importance to justify the reference of the families with united pharyngeals to a subordinal group of equal rank with one containing those in which these bones remain distinct; but we prefer to follow

Day in regarding the group now to be considered merely as a section of the suborder which includes all the other spiny-finned fishes. That this is the correct view is proved by the circumstance that in one aberrant genus of perches (*Gerres*) some of the species have the lower pharyngeal bones separate, while in others they are united. In the three families constituting the present group there is a single dorsal fin, in which the number of spines and soft rays is nearly equal; while the anal is usually similar in character to the soft dorsal; and the pelvic fins are thoracic in position, and include one spine and five soft rays.

Pomacentrus

The first of the families of the present sectional group takes its name from the genus *Pomacentrus*, which, together with the allied genera, includes tropical fishes mainly frequenting the neighborhood of coral reefs and islands, and thus closely resembling the scaly-finned fishes (p. 2710) in their mode of life; a few species of the family range, however, into the seas of the temperate zones. As an example of the typical genus, we figure *P. scolopsis*, from the Malayan seas and Polynesia. As a family these fishes are specially characterized by the presence of false gills and ctenoid scales. In form, the body is more or less short and compressed; there are weak teeth in the jaws but none on the palate, and there is an air bladder. The family is represented by eight genera and considerably over a hundred species; and the genera may be divided into groups, according as to whether all or some of the opercular bones are serrated at the edges or are all simple; *Pomacentrus* belonging to the intermediate group, in which the preopercular is serrated, while the edges of the other bones of the gill cover are entire. In a fossil state the family is represented by an extinct genus from the middle Eocene deposits of Monte Bolca. *Pomacentrus* is the largest genus of the family, its representatives ranging over the tropical seas of both Hemispheres. Curiously enough, not only do these fishes resemble the scaly-finned fishes in their mode of life, but they are very similarly colored, so much so, indeed, that in some instances actually the same pattern of coloration is common to members of the two families. This, as remarked by Dr. Günther, is one of many instances showing that the coloration of animals depends to a great extent on their mode of life and natural surroundings. All these fishes are carnivorous, subsisting on various small marine animals; those furnished with compressed teeth probably browsing on the coral polyps.

Wrasses

Distinguished from the preceding family by their cycloid scales, the wrasses form an extensive group (*Labridæ*), many of the members of which may be easily recognized by their greatly thickened lips, sometimes provided with an internal fold; and from this characteristic they derive their German title of lip fishes. False gills are present, and the true gills, three and a half in number on each side. The body is oblong or elongate, and while teeth are present in the jaws they are absent on the palate. In the single dorsal fin the number of spines is usually equal to that of the rays; the anal is similar to the soft dorsal, and an air bladder is present. Littoral in their habits, the great majority of the wrasses are found in tropical and temperate seas, none occurring within the limits of the polar seas. Rocks and coral reefs are their favorite haunts, most of them feeding chiefly on mollusks and crustaceans, for crushing the shells of which their teeth are specially adapted. In many kinds there is an additional pointed curved tooth at each angle

of the upper jaw, used for holding a shell against the front and side teeth, by which it is crushed. The majority of the wrasses are beautifully-colored fishes, decorated not only with transient iridescent hues on the scales, but likewise with permanent colors formed by the deposition of pigment in the tissues. Some of the species grow to a large size, specimens weighing upward of fifty pounds; and it is these larger species which are most esteemed as food fishes, the flesh of the smaller kinds being of inferior quality. In a fossil state wrasses date from the middle Eocene of Monte Bolca, where remains referable to the existing genus *Labrus* occur; while an extinct Eocene genus from North America appears to be the ancestral form of the existing blackfish (*Tautoga*). An allied extinct family is represented by *Phyllodus*



STRIPED WRASSE.
(One-third natural size.)

from the Cretaceous and lower Eocene of Europe — distinguished by the flattened leaf-like pharyngeal teeth — as well as by several other more or less nearly related Tertiary types.

True Wrasses

As it would be quite impossible in our limited space to describe even a few of the numerous genera of wrasses, we must content ourselves with saying that these are arranged in groups according to the structure of the anterior teeth, and devote our remaining observations mainly to the typical wrasses constituting the genus *Labrus*. In this genus, of which the figured striped or red wrasse (*L. mixtus*) may be taken as a well-known British example, the body is compressed and oblong in form, with the moderate-sized scales arranged in more than forty transverse rows; the muzzle is more or less sharply pointed; the cheeks

and opercular bones are covered with imbricating scales, which are, however, wanting or but few in number on the interopercular; and the conical teeth are arranged in a single row in the jaws. The spines of the dorsal fin are numerous, varying from thirteen to twenty-one, and are all of approximately equal height; there are three spines in the anal fin; and the lateral line is continuous. In the young, the edge of the preopercular bone is serrated. These wrasses are chiefly characteristic of the Mediterranean area, gradually diminishing in the more northern seas of Europe, and being quite unknown in those of India. The striped wrasse exhibits a remarkable sexual variation of color; the males usually having the body marked with blue streaks or a blackish band, while in the females the back of the tail shows two or three blackish blotches. The other British species is the Ballan wrasse (*L. maculatus*), in which the general color is bluish green, the scales being margined with reddish orange, and the fin rays also of the latter tint. Couch writes that the Ballan wrasse "frequents deep gullies among rocks, where it shelters itself among the larger kinds of seaweeds, and feeds on crabs and other crustaceous animals. It takes a bait freely, and fishermen remark that when they first fish in the place they take but few, and those of large size; but on trying the same spot a few days after, they catch a great number, and those smaller, from which they conclude that the large fish assume the dominion of a district, and keep the younger at a distance." The gold sinny (*Crenilabrus melops*) is a British example of a second genus, distinguished by the serrated edge of the preopercular. Another well-known member of the family is the blackfish (*Tautoga onitis*) of the Atlantic coast of North America, so named on account of its blackish-brown color, and the sole representative of a genus characterized by the naked opercular, the rudimental scales on the cheek, and the double row of teeth in the jaws.

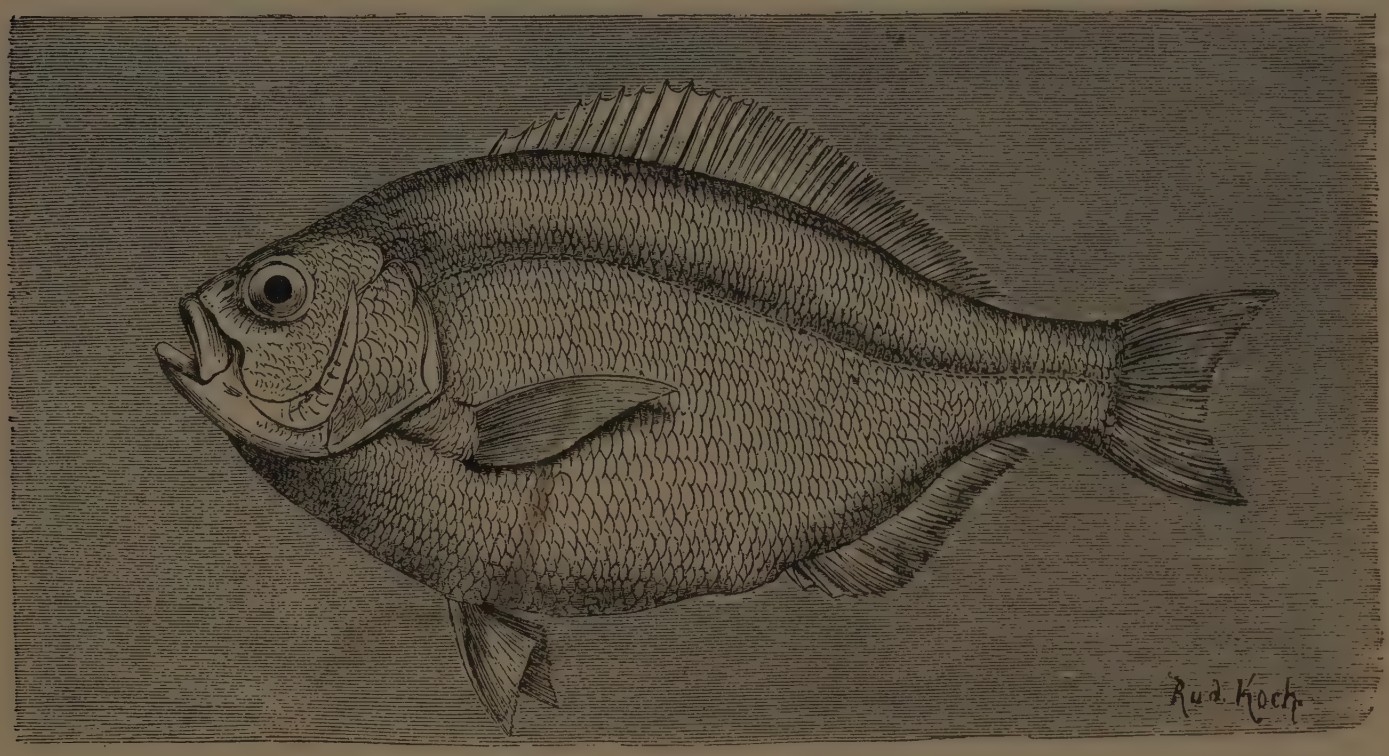
Parrot Wrasses

Since their Mediterranean representative (*Scarus cretensis*) was a fish held in high estimation among the ancients, brief mention must be made of the parrot wrasses, of which the other species are inhabitants of the tropical parts of the Atlantic. These fishes are easily recognized by their sharp beak, caused by the coalescence of the teeth; and also by the lower jaw projecting in front of the upper. Of the splendidly-colored Mediterranean species Dr. Günther writes that "it was most plentiful and of the best quality in the Carpathian Sea, between Crete and Asia Minor, but was not unknown, even in early times, on the Italian coasts, though Columella says it seldom passed beyond Sicily in his day. But in the reign of Claudius, according to Pliny, Optalus Elipentius brought it from the Troad, and introduced it into the sea between Ostium and Campania. For five years all that were caught in the nets were thrown into the sea again, and from that time it was an abundant fish in that locality. In the time of Pliny it was considered to be the first of fishes; and the expense incurred by Elipentius was justified, in the opinion of the Roman gourmands, by the extreme delicacy of the flesh." This fish feeds on seaweed; and the mastication required to reduce this to a pulp probably gave rise to the old idea that it was a ruminant.

For the want of a better one, the members of the small family *Ditrematidæ* may be termed, on account of their peculiar reproductive arrangements, viviparous

Viviparous Wrasses

wrasses. Agreeing with the wrasses in the presence of false gills and the cycloid scales, they differ in having four gills, and the anal fin furnished with three spines and numerous soft rays. In form, the compressed body is either elevated or oblong, and the lateral line continuous. The single dorsal fin has a spinous portion in front, and a scaly sheath along the base, separated by a groove from the body scales. Small teeth are present in the jaws, but the palate is toothless. Generally not exceeding a pound in weight, these fishes are confined to the temperate region of the North Pacific, where they are much more numerous on this than on the Asiatic side. While the majority belong to the genus *Ditrema*, of which an example (*D. argenteum*) from San Francisco is represented in the illustration, one species constitutes the genus *Heterocarpus*, distinguished by the number of dorsal spines being from sixteen to eighteen, instead of from seven to eleven. All these fishes produce living young, which are contained in the sheath of the ovaries, instead of the oviduct.

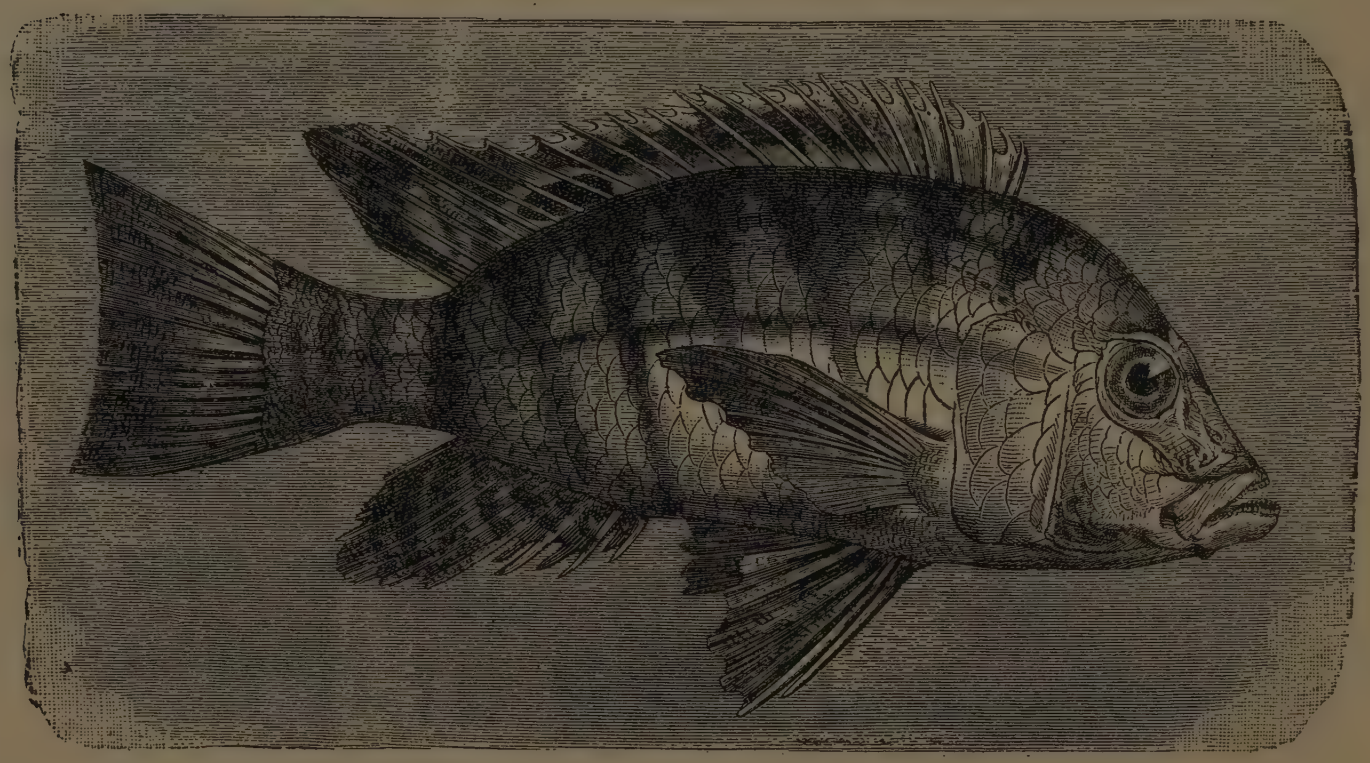


SILVERY VIVIPAROUS WRASSE.
(Two-fifths natural size.)

Chromids

Although some members of the preceding family may occasionally enter rivers, the chromids, family *Chromididæ*, differ from all the other fish with united lower pharyngeals in being exclusively fresh-water forms. Their distribution is somewhat peculiar, and very similar to that of the lungfishes (exclusive of the Australian form). Thus they are found in the rivers of tropical America and Africa, together with Madagascar, Syria, and Palestine, one outlying genus occurring in India; and it may be remarked that all the genera from the New World are distinct from those of the Old World. Mostly of comparatively-small size, although one species of the type genus from the Nile grows to a length of about twenty inches, the chromids may be distinguished from all the other three families of the present group by the absence of false gills. The body, which is somewhat

variable in form, is generally covered with ctenoid scales, although in some cases these may be cycloid; and the lateral line is more or less interrupted. In the single dorsal fin the spinous portion usually exceeds the soft in extent; the anal fin having three or more spines, and its rayed portion being similar to the soft dorsal. The jaws are provided with small teeth, but the palate is smooth; and the number of gills is four. In some species the teeth are lobate and the intestines complicated by many foldings; these types being vegetable feeders while all the remainder are carnivorous. Among the best-known representatives of the typical genus *Chromis* is the so-called butti of the Nile (*C. niloticus*), which is one of the largest members of the family; while Tristram's chromid (*C. tristrami*) here figured is from salt and other lakes in the Sahara and Ashanti. As a genus, *Chromis* is distinguished by its lobate teeth, the presence of only three spines in the anal fin, and the scaly gill



TRISTRAM'S CHROMID.

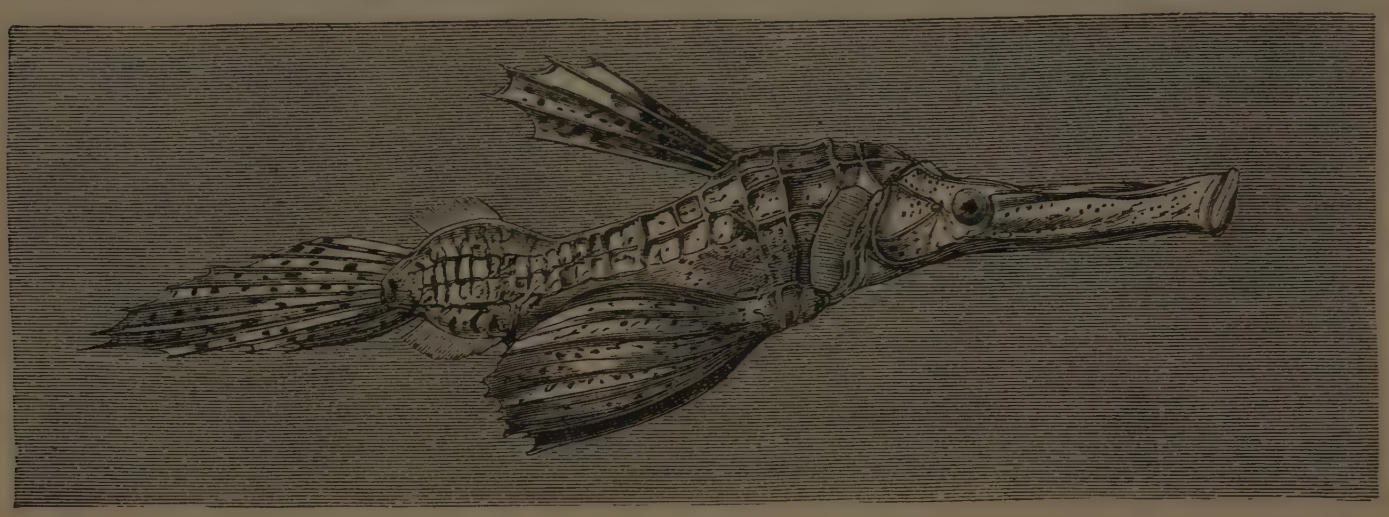
cover; and it therefore belongs to the vegetable-feeding group. Nineteen existing genera have been described; and the family appears to be represented by one, or perhaps two extinct generic types from the middle Eocene of Monte Bolca, in Italy.

The Tuft-gilled and Comb-gilled Fishes — Suborders Lophobranchi and Plectognathi

The two small subordinal groups of fan-finned fishes now to be noticed have been generally placed after the soft-finned fishes, but from recent investigations into their anatomy it appears more probable that they are highly specialized types related to the spiny-finned group.

The Mailed Tube Mouths — Family *Solenostomatidæ*

A few small fishes from the Indian Ocean constituting the genus *Solenostoma* are the sole representatives of the first family of the suborder Lophobranchii; the distinctive features of that subordinal group being as follows: The body is invested in a segmented bony dermal skeleton, and the bones of the gill cover are reduced to a single plate. The gill openings are small, and the gills themselves consist of small rounded tufts springing from the gill arches; while the muscular system is characterized by its very slight development. The simple air bladder, when present, resembles that of the spiny-finned group in being unprovided with a duct communicating with the pharynx; and the prolonged muzzle terminates in a small toothless mouth, in which the bones are arranged as in the group last named. In the family under consideration the gill openings are wide; the rays of the first of the two dorsal fins are not articulated; and the whole of the other fins are well developed. The mailed tube mouths take their title from the great elongation of



BLUE-FINNED TUBE MOUTH.
(Natural size.)

the tube-like muzzle; the compressed body having a very short tail, and, like the head, being covered with a thin skin, beneath which are the large bony plates, marked with a radiate pattern. The soft dorsal and anal fins arise from boss-like elevations of the hinder part of the body; the pelvic fins, which are placed close together in the same vertical line as the tail first dorsal, and have seven rays, are separate from one another in the males, but in the opposite sex have their inner edges joined to the skin of the chest so as to form a pouch for the reception of the eggs. The air bladder is wanting. A female of the blue-finned species (*S. cyanopterum*) is shown in the accompanying illustration; the range of this form extending from the coast of Zanzibar to China and Ceram. The female takes the whole charge, not only of the exceedingly-minute eggs, but likewise of the newly-hatched fry. Like the members of the next family these fishes generally swim in a more or less nearly vertical position, the dorsal fin exerting the chief propelling power. The family is represented by an extinct genus from the Italian Eocene.

The Pipefishes and Sea Horses — Family *Syngnathidæ*

From the members of the preceding family the pipefishes may be distinguished by the reduction of the gill opening to a very small opening at the superior hinder angle of the gill cover, as well as by the single soft dorsal fin, and the absence of the pelvic fins; some of the other fins being likewise wanting in certain genera. Mainly marine, although frequently entering brackish, and more rarely fresh waters, these strange fishes are to be found on the coasts of tropical and temperate seas in



GREAT PIPEFISH AND SHORT-SNOUTED SEA HORSE.
(One-half natural size.)

such situations as, from the abundance of seaweed, offer them sufficient shelter. They are naturally poor swimmers, and if carried away from protective covert may be borne helplessly out to the open ocean by the action of curreuts. Unlike the tube mouths, the males take charge of the eggs and young, being often provided with a pouch formed by a fold of skin arising from each side of the body and tail, and joined together in the middle line; in the sea horses this pouch being completely closed, save for a small aperture in front. In this receptacle the eggs are deposited, and remain there till hatched. The typical genus, as well as *Siphonostoma*, is rep-

resented in a fossil state in the middle Eocene of Monte Bolca, where there likewise occurs an extinct genus of sea horses. Including several genera, the pipefishes are characterized by the absence of prehensile power in the tail, which generally terminates in a fin. In the typical genus *Syngnathus*, as represented by the great pipefish (*S. acus*), shown in our illustration, the body is marked with more or less distinct longitudinal ridges, among which the one down the back is not continuous with that on the tail. The pectorals are well developed, the caudal present, and the dorsal fin placed nearly or exactly above the vent. In the males the pouch is fully developed, and of the type described above. The great pipefish is a common



FUCUS-LIKE SEA HORSE.
(Two-thirds natural size.)

species in European seas, extending westward across the Atlantic and southward to the Cape, and grows to a length of a foot and a half. As an example of a second genus, we may mention the deep-nosed pipefish (*S. typhle*) of the British seas distinguished by the upper ridge on the tail being continuous with the lateral line, but not with the dorsal ridge. In the tropical genus *Doryichthys*, as in some others, we find that the eggs are only glued to the skin of a broad groove on the under surface of the males, instead of being protected by a closed pouch. The slender straight-nosed pipefish (*Nerophis ophidium*), which may not unfrequently be seen served up among a dish of whitebait, is a British example of a fourth genus, in

which not only is there no pouch on the under surface of the males, but the body is rounded and nearly smooth, and the caudal fin either rudimentary or wanting. All the pipefishes are carnivorous in their diet; and it is stated that in those species provided with a pouch, the fry will return to this for shelter for a considerable time after birth. The pipefishes swim about slowly in a very peculiar manner, more generally vertically or in an inclined position than horizontally, contorting their bodies into every conceivable kind of posture, and poking their long snouts inquisitively into bunches of seaweed in their search for food.

The prehensile structure of the tail is the chief difference between sea horses and pipefish, although in all the existing representatives of the former group there is no caudal fin. The sea horses are divided into several genera, of which the typical one is best known by the short-snouted sea horse (*Hippocampus antiquorum*), ranging from the Atlantic and Mediterranean to Australia, and occasionally found in the British seas. In this genus the body is more or less compressed and deep, with its investing bony shields raised into tubercles or spines of variable length; while the back of the head is compressed into a crest, terminating in a well-marked knob. Small pectoral fins are present, and the males have a pouch beneath the tail, with its aperture near the vent, in which to carry the eggs. The curious resemblance presented by the heads of these fishes to that of a horse has obviously given rise to their popular name. They are represented by about a score of species. A remarkable instance of resemblance to their natural surroundings is afforded by the three representatives of an Australian genus of sea horses, one of which (*Phyllopteryx eques*) is shown in the preceding illustration. In these fishes the body may be either compressed or as broad as deep; some or all of its smooth bony plates being furnished with long spine-like processes projecting from its edges, and many of these terminating in irregular leaf-like appendages. There are a pair of spines on the muzzle, and others above the eye; pectoral fins are present; and the tail is about equal in length to the body. In the absence of a pouch, the eggs are embedded in soft membranous skin on the under surface of the tail. These sea horses closely resemble the color of the seaweeds to which they attach themselves, while the filamentous appendages of their spines appear as if they were actually a part of the vegetable growth. These species are of relatively-large size, attaining a length of as much as a foot.

Filefishes and Coffer Fishes—Family *BALISTIDÆ*

With the filefishes and their allies we come to the first of the two families constituting the suborder Plectognathi, of which the following are the distinctive characteristics: In the head the bones are completely ossified, while in the rest of the skeleton they are incompletely hardened; the number of vertebræ being few. The small gill openings are situated in front of the pectoral fins, and the gills themselves are pectinate; the mouth being narrow, with some of the bones of the upper jaw united, and in certain cases both jaws prolonged to form a beak. There is gen-

erally a single soft-rayed dorsal fin, placed far back on the body, and situated immediately above the anal; and there may be remnants of a spinous dorsal; while the pelvic fins, when retained at all, take the form of simple spines. The skin may be either entirely naked, covered with rough scales, invested in a complete cuirass of plates composed of true bone, or dotted over with bony spines. There is no duct connecting the air bladder with the pharynx. As a family, the filefishes and their allies are specially distinguished by the presence of a small number of distinct teeth in the jaws. Their bodies are either compressed or angulated, with a somewhat produced muzzle; more or less distinct vestiges of a spinous dorsal and pelvic fins generally occur; and the skin may be either rough or spiny, or the whole body invested in a bony cuirass. These fishes, which are of medium size, range over all tropical and temperate seas, although more numerous in the former than in the latter, and may be divided into three subfamilies, in each of which we notice an example. Extinct generic types date from the period of the lower Eocene, while the filefishes themselves are recorded from the middle Eocene of Monte Bolca.

The first subfamily is typically represented by *Triacanthus brevirostris* from the Indian Ocean, the other genera being from the Australian seas. The special characteristics of the group are to be found in the compressed form of the body, and its covering of rough, scale-like plates, as well as in the presence of a pair of strong spines representing the pelvic fins; the type genus being distinguished by having from four to six spines in the spinous dorsal fin. The typical filefishes (*Balistes*) belong to a group of three genera in which the body is compressed, and covered either with a rough skin or movable scale-like plates; and the pelvic fins are either wanting or represented merely by a single median swelling on the abdomen. These fishes are distributed over all tropical and subtropical seas; the first two genera including a very large number of species. Whereas in the typical genus there are three spines to the dorsal fin, and the chin is devoid of a barbel, *Monacanthus* differs in the reduction of the dorsal spines to two or one, and *Anacanthus*, which has a single dorsal spine, is distinguished from both the others by the barbel on the chin. In many districts the flesh of these fishes, if eaten, gives rise to symptoms of most acute poisoning. Many of the species are beautifully ornamented with symmetrical markings; and while the majority are of small size, some attain as much as a couple of feet in length. Of the members of the typical genus Dr. Günther writes that "both jaws are armed with eight strong incisor-like and obliquely truncated teeth, by means of which these fishes are enabled to break off pieces of the corals on which they feed, or to chisel a hole into the hard shells of mollusks, in order to extract the soft parts. They destroy an immense number of mollusks, thus becoming most injurious to the pearlfisheries. The first of their three dorsal spines is very strong, roughened in front like a file, and hollowed out behind to receive the second much smaller spine, which, besides, has a projection in front at its base, fitting into a notch of the first. Thus these two spines can only be raised or depressed simultaneously, and the first cannot be forced down unless the second has been previously depressed. The latter has been compared to a trigger, hence a second name — trigger fish — has been given to these fishes." Two Atlantic species of the genus are now and then met with on the British coasts.

The box-like coffer fishes (*Ostracion*) of which there are rather more than a score of species from the tropical and subtropical seas alone represent the third and last subfamily, and are easily recognized by the inclosure of the angulated body in a complete cuirass formed of six-sided bony plates with their edges in juxtaposition, thus forming a mosaic-like pattern. Both the spinous dorsal and the pelvic fins are wanting, although their position may be indicated by prominences. In the whole backbone there are but fourteen vertebræ, of which the last five are very short, while those in the front of the series are much elongated, and the ribs are entirely wanting. In some of the species the cuirass is marked by three, and in others by four or even five ridges; but in other cases it is armed with long spines, which vary in length according to the age of their owner. A species (*O. quadricornis*) is figured in the colored plate.

The Globefishes and Sunfishes — Family *Diodontidæ*

Unlike as they are in external appearance, the spine-clad globefishes and the huge flattened sunfishes are referred to a single family, distinguished from the last by the bones of the jaws being confluent and modified into a cutting beak, which may or may not have a median suture, the dentition taking the form of dental plates composed of thin parallel layers. The body is more or less shortened; a spinous dorsal, anal, caudal, and pectoral fins are developed, but the pelvics are wanting. The external covering may take the form either of a number of small or large spines, or of plates; and the air bladder may be either present or absent. Inhabitants of tropical and subtropical seas, with the exception of a few found in the fresh waters of the same regions, the members of this family are mostly small or medium-sized forms, although this is by no means the case with the sunfishes. In many of them the flesh is of a highly poisonous nature, at least during certain seasons of the year. Like the preceding, the present family may be divided into three groups or subfamilies, the first of which is represented only by the sac fish (*Triodon bursarius*) of the Indian seas, which takes its name from the sac formed by the dilatable skin of the abdomen; this sac being supported by the pelvic bone, and filled with air at the will of the fish, although its lower portion consists merely of a flap of skin into which no air can enter. The dental plate of the upper jaw is divided by a median suture, while that of the lower jaw is continuous. The elongate tail terminates in a forked fin, and the body is invested with spiny bony plates, which do not overlap one another. The single species, which may attain a length of twenty inches, ranges over the Indian and Malayan seas, and is of a general brown color, with a spot of variable color on the sac, and the fins yellow.

Globefishes

The essential characteristics of the globefishes, which form the second subfamily, are that the tail and its fin are distinct and well developed, and that a portion of the œsophagus is highly distensible and capable of being inflated with air. All the globefishes, or, as they are sometimes called, sea hedgehogs, are easily recognized by the short and cylindrical or rounded form of the body, which is generally covered with a scaleless skin bearing a number of spines of



GLOBE FISH AND COFFER FISH.

variable size. When these spines are of large size, they are spread uniformly over the whole body, but when small they are partial in their distribution. These fishes are divided into two groups, according to the nature of the dental plates. In the first, or small-spined group, as typified by the genus *Tetrodon*,— of which a species is represented in the lower figure of the colored plate,— the dental plate of each jaw is divided by a median suture, and the spines are frequently very small, and may be even altogether absent; many of the species being very brilliantly colored. One member of the genus inhabits the rivers of Brazil, and a second those of West Africa and the Nile, while a small form is found in the brackish-water estuaries of India. According to Day, the flesh of some of the species is poisonous, while that of other kinds is eaten by the Andamanese and Burmese. In the second group, of which the porcupine globefish (*Diodon hystrix*) is shown in the lower figure of the colored illustration, the dental plates in the jaws are undivided, and the spines are large and frequently erectile. In addition to the undivided dental plates on the edges of the jaws, in the members of this group there is another crushing plate in the middle of the palate, opposed by a similar one in a corresponding position in the lower jaw; these plates being divided by a median suture and from their laminated structure forming most admirable triturating instruments. The porcupine globefish, which may measure fully a couple of feet in length, is distributed over both the Atlantic and Indo-Pacific Oceans, where it is accompanied by the smaller spotted globefish (*D. maculatus*). Fossil diodons have been discovered in the Miocene strata of Malta and Sicily, as well as in the middle Eocene of Monte Bolca, and in other Eocene beds on the coasts of Algeria and Arakan; while an extinct genus has also been recorded from the Italian Eocene. In their normal state the globefishes have rather elongated cylindrical bodies, but they are able to assume a globular form by swallowing air, which passes into the œsophagus and blows out the whole animal like a balloon, with the spines standing out at right angles from the tense skin. In this condition the fish naturally floats back downward, and it is then driven to and fro on the ocean surface by waves and currents in a perfectly helpless condition; although the bristling spines render it perfectly safe from all attack. The distension is, therefore, evidently for the purpose of defense; and it has been suggested that when swimming below the surface these fishes may inflate themselves in a similar manner by swallowing water instead of air. When desirous of returning to its normal condition, the fish expels the air from the œsophagus through the mouth and gill openings; a loud, hissing noise being produced by the expulsion.

Sunfishes

The gigantic sunfishes (*Orthagoriscus*), which are pelagic forms distributed throughout the whole of the temperate and tropical seas, alone represents the third subfamily, and are distinguished by the extremely short and truncated tail, the confluence of all the median fins, and the short and highly compressed body, the dental plates of the jaws being undivided. The skin is either rough or smoothly tesselated, and incapable of distension with air; there are no pelvic fins; the air bladder is wanting; and there is an accessory opercular gill. As in the globefishes, there are no pelvic bones in the skeleton, and the vertebral column is remarkable for its extreme shortness, there being only seventeen

segments in the whole series, of which seven belong to the tail. In all the members of the suborder the spinal cord is noticeable for its shortness; but in the sunfishes this abbreviation has been carried to such an extent that the whole cord is little more than a conical backward appendage of the brain. The creatures considered to be very young sunfish are utterly unlike the adult form, having an enormous eye, and the head and body armed with a number of large spine-like projections. The caudal fin is not developed till much later than the dorsal and anal, which in the adult are very short, of great height, and placed opposite to one another at the hinder end of the body. The common sunfish (*O. mola*), which has a rough, finely granulated skin, attains very large dimensions, an example caught off the coast of Dorsetshire in 1846 measuring seven and one-half feet in length.

Far rarer is the oblong sunfish (*O. truncatus*), which is, indeed, one of the scarcest objects in museums. It is readily distinguished by its smooth, tesselated skin, and the more elongated form of the body; the entire length being nearly three times the breadth. An example of this fish, weighing five hundred pounds, was taken in Plymouth Sound in the year 1734. Both species appear to feed on small pelagic crustaceans. In a fossil state sunfishes have been recorded from strata of lower Miocene or upper Eocene age in Belgium.

The Soft-finned Fishes — Suborder **Anacanthini**

This suborder, which includes the important families of the flatfish and cods, is characterized by the median and pelvic fins being entirely composed of soft jointed rays; the pelvic fins, if present, being either jugular or thoracic in position; and the air bladder, when developed, having no duct communicating with the œsophagus. It should, however, be mentioned, that a fresh-water Australian fish (*Gadopsis*) forms an exception as regards the structure of its fins, having spines in the anterior portion of both the anal and dorsal. The suborder is divided into two sections, according to whether the head and body are symmetrical or distorted, the first representatives of the former section being

Family *LYCODIDÆ*.

This unimportant family, for which there is no proper English name, includes small littoral fishes much resembling blennies in general appearance, and mostly characteristic of high latitudes, although a few occur within the Tropics. As a family they are characterized by the confluence of the median fins; by the pelvic fins, if present at all, being of small size, jugular in position, and attached to the pectoral arch; while the gill opening is narrow, and the gill membrane attached to what is known as the isthmus, that is to say, the space on the chest intervening between the two branches of the lower jaw and the gill openings. In the typical genus, of which a species (*Lycodes muræna*) is represented in our illustration, the

elongated body is either naked or covered with minute scales embedded in the skin; the lateral line is more or less indistinct; the eyes are of medium size; and the lower jaw is overlapped by the upper. The small and rudimentary pelvic fins are formed of a few rays; conical teeth are present not only in the jaws, but likewise on the palatines and vomer; the gill opening is narrow; and there is neither a barbel nor an air bladder. While the majority of the species (among which is our figured example) are from the Arctic seas a few are found in the seas surrounding the Antarctic extremity of South America. In Spitzbergen and off Behring island the eel-like lycodes is taken at depths of from three hundred and fifty to five hundred fathoms.



EEL-LIKE LYCODES.
(Two-thirds natural size.)

In the allied genus *Gymnelis*, which is of especial interest from a geographical point of view on account of one species inhabiting the seas around Greenland, while the second comes from the straits of Magellan, there are no pelvic fins, and the two jaws are of equal length. A third genus, *Uronectes*, from Baffin bay, agrees with the last in the absence of pelvic fins, but differs in that the lower jaw is the longer. Three other genera are respectively represented by species from Panama, Australia, and the straits of Magellan.

The Cod Tribe — Family *GADIDÆ*

Equalled only in this respect by the mackerels, flatfish, salmon, and herrings, the cod tribe form a family of the utmost importance from a commercial point of view, and therefore demand a somewhat detailed notice. They are specially characterized by the pelvic fins being generally composed of several rays; and by the caudal being either free, or, if united with the median fins, by the first dorsal being divided into two moieties. More or less elongate and subcylindrical in form, the

body is covered with small cycloid scales; there are either one, two, or three dorsal fins, occupying nearly the entire length of the back, the rays of the hindmost being well developed; the anal is either single or divided; and the jugular pelvic fins are usually formed of several rays, but if reduced to filaments there is always a double dorsal. The gill opening is wide, and the gill membrane in most instances not at-



HADDOCK, WHITING, AND YOUNG AND ADULT COD.
(One-sixth natural size.)

tached to the isthmus; while if false gills are present at all they are either glandular or rudimental. As a rule, there is an air bladder. Mostly marine, the members of the cod family are mainly characteristic of the Arctic and Temperate seas, where they are comparatively shallow-water fishes. There are, however, a certain number of deep-water types among the family, and these have a much more extensive distribution, some of them occurring in the tropical Indian seas. The fresh-water

forms are limited to two or three. Although the flesh of the cod tribe is by no means remarkable for its delicacy or flavor, it affords a most wholesome and substantial food, and as it possesses the property of taking salt readily, it is more valuable as a food supply than would otherwise be the case. Moreover, the liver of the cod is of especial value as the source of a highly strengthening medicinal oil, greatly increasing the value of the fishery of this species, which affords employment to a host of men on both sides of the Atlantic. The family is divided into more than twenty distinct genera, but in this work our attention will be chiefly concentrated on those containing species of commercial importance. Geologically the group is not a very ancient one, the oldest known forms, all of which are referred to extinct genera, occurring in the London Clay and other deposits of lower Eocene age.

Cod

The common cod (*Gadus morrhua*) of which a half-grown and an adult example are shown in the two lower figures of our illustration is the typical representative of a genus primarily characterized by the presence of three dorsal and two anal fins, and of teeth on the vomer, the palatine bones being toothless. The degree of elongation of the body is moderate, and the narrow pelvic fins include six or more rays. In the majority of the eighteen species recognized by naturalists there is a single barbel dependent from the chin, but in some forms this is absent. The species are distributed over the Arctic and Temperate regions of the Northern Hemisphere. The common cod belongs to a group of several species characterized by the upper jaw being the longer, and the outer series of upper teeth stouter than the inner ones; its barbel is relatively long. Cod from the British seas and German Ocean are usually greenish or brownish olive in color, with a number of yellowish or brown spots; but more to the north darker, and often uniformly-colored specimens are more common, while in the race from Greenland, Scandinavia, and Northern Norway there is frequently a large, irregular black patch on each side of the body. As a rule, cod vary in length from two to four feet, and may weigh as much as one hundred pounds; but a specimen out of condition, caught near Wick in the year 1872, measured upward of four and one-half feet. The range of the cod includes the coasts of Northern Europe, Iceland, and Greenland, whence it descends on the American coast as far as the latitude of New York; the depth at which the fish is found extending as low as one hundred and twenty fathoms. In Britain the spawning time is in January, at which season these fish resort to the shores in great numbers, although at other times of the year they are only found in the neighborhood of land singly. In America cod do not deposit their spawn till May. The great fisheries are those of the Dogger Bank in the North Sea, Iceland, and the banks of Newfoundland; the product of the latter area having been formerly the greatest of all, its average value some twenty years ago being estimated at upward of $3,000,000, of which $2,000,000 was accounted for by the dried fish alone, the remainder being made up by the oil, skins, etc. The cod is an exceedingly productive fish, Buckland stating that the number of eggs in a roe weighing seven and three-fourths pounds, was close on seven millions. Cod feed on various crustaceans, worms, mollusks, and small fish; and since they always frequent comparatively deep water, they are caught by means of lines.

Haddock

Belonging to the same group of the genus as the common cod, the haddock (*G. æglefinus*), which is shown in the left upper figure of the illustration on p. 2804, may be always recognized by the blackish patch on each side of the body above the pectoral fin, and the black lateral line. Generally haddock vary in weight from one-half to four pounds, but in northern seas they attain a larger size than further south, and measure as much as a yard in length. In England the largest haddock are taken in winter, when they resort to the coast for the purpose of spawning. They generally associate in large shoals; and in stormy weather seek shelter in deep water among seaweeds, when it is useless to attempt fishing for them. In addition to crustaceans and other invertebrates, their food comprises small fishes of various kinds. Haddock are largely consumed when split, dried, and smoked. They range across the Atlantic.

Other Species

By far the most delicately-flavored British representative of the genus is the whiting (*G. merlangus*), shown in the right upper corner of the illustration on p. 2804, which differs from all the preceding species in the absence of a barbel on the chin, and is specially distinguished by a black spot near the root of each pectoral fin. The usual weight is about one and one-half pounds; four pounds being nearly the maximum attained. The distributional area of the whiting is restricted to the seas of Northern Europe, where it is found in vast shoals; Plymouth being one of the British localities where these fish occur in great abundance. Very shy in its habits, the whiting is a voracious fish, Yarrell stating that several sprats have been taken from the stomach of one, while in another of four pounds weight were found four full-grown pilchards. The same writer states that it appears to prefer sandy banks, but frequently shifts its ground in pursuit of the fry of various other fishes on which it chiefly feeds. Next to the mackerel, the whiting suffers more by transport than any British sea fish, and should be eaten as soon as possible after capture. Another species with a black spot near the pectoral fin is the pout, or whiting pout (*G. luscus*), which may be at once distinguished from the whiting by the barbel on the chin, and the greater depth of the body, which during life is marked with dark cross-bands. Seldom exceeding five pounds in weight, this fish ranges from Scandinavia to the Mediterranean, but does not cross the Atlantic. The name of pout is derived from the power possessed by this fish of inflating the membranes covering the eyes and adjacent regions into a bladder-like form. Nearly allied is the much smaller power cod (*G. minutus*), which seldom exceeds half a dozen inches in length, and may be further distinguished by the small proportionate depth of the body. Found in vast shoals in the Baltic, the power cod, although of little or no value, is always welcomed as the harbinger of the advent of its larger cousins. The pollack, or whiting pollack (*G. pollachius*), is a British representative of the group in which the lower jaw is the longer, and all the upper teeth are of equal size; it has a dark spot near the pectoral fin, but no barbel. This fish is an inhabitant of European seas as far as the western portions of the Mediterranean. Haunting rocky ground, pollack are famous for their power of withstanding strong tides and currents; they are very common in many parts of the south coast of England, as Devonshire, but become

scarcer to the north. Being free biters, they afford good sport with the line. The coalfish (*G. virens*) is a closely allied but somewhat larger form, more northern in its distribution, and taking its name from the black color it frequently assumes. This fish is very common in the Baltic and other northern seas, numbers being captured in the Orkneys. The largest specimen on record appears to be one mentioned by Buckland, which measured just over three and one-half feet in length, and scaled twenty-five pounds.

Hakes

Before referring to this species it may be mentioned that a deep-sea cod (*Halargyrcus*), which has been taken off Madeira and New Zealand, belongs to a small group characterized by having two dorsal and two anal fins. On the other hand, the hake (*Merluccius vulgaris*) is the British representative of a genus belonging to a much larger group, characterized by having two dorsals, a single anal, and a separate caudal fin. As a genus, the hakes are distinguished by the strong development of the pelvic fins, which are broad at the base, as well as by the presence of strong teeth on the jaws and vomer, and the absence of a barbel. The common hake is found on both sides of the North Atlantic and other European seas; and is represented in the colder seas of South America, as well as in those of New Zealand, by the allied *M. gayi*. The hakes are peculiar in having the transverse processes of some of the trunk vertebræ expanded and inflated, so as to form a kind of roof over the air bladder. In size the common hake is a rather large fish, reaching two or even three feet in length. On the Cornish coasts, which they frequent in numbers in pursuit of the shoals of pilchards, hake have been taken in vast quantities, upward of forty thousand having once been landed in a day at Mount's bay, while on another occasion eleven hundred were taken in two nights by a single boat. When captured in the pilchard nets, these fish generally gorge themselves to such an extent on their fellow captives as to become completely helpless. Although the flesh is coarse and of inferior flavor, large numbers of hake are dried and salted.

Burbot

As an example of a fresh-water representative of the cod family, we may refer to the well-known burbot or eelpout (*Lota vulgaris*) which is the sole member of its genus, and is common in the rivers of Central and Northern Europe and North America. Belonging to the group with two dorsals, one anal, and a distinct caudal, the genus *Lota* has the first dorsal fin well developed, with from ten to thirteen rays, the pelvics with several rays, the head flattened, the body much elongated, and villiform teeth in the jaws and on the vomer. The chin is furnished with a barbel. In length the burbot exceeds a yard, and its flesh ranks high among fresh-water fish. Its form is shown in the uppermost figure of the illustration on p. 2808. In Britain found only in the east of England, where it is not uncommon in the Cam and the Ouse, the burbot is widely distributed on the Continent, frequenting alike large rivers, small streams, lakes, and pools. It prefers, however, deep to shallow water, being found in large lakes at a depth of from thirty to forty fathoms; its color being then paler than is the case with specimens from shallower water. From its habit of lying concealed beneath stones or in holes on the river bank, the burbot in some parts of England is known as the coney fish. Its food consists of the fry of other fishes, or the

adults of the smaller kinds; and it is stated to be particularly destructive to the perch. In the spawning season, which varies considerably according to localities, burbot are in the habit of congregating in large numbers; and in some of the German rivers masses of these fishes, including as many as a hundred individuals, may be found knotted together after the fashion of eels. While some burbot spawn



BURBOT AND WELS, immature.
(One-fourth natural size.)

in November and December, in others the function is delayed till March; and it is during the spawning season that the fish is in the best condition for the table. The burbot is a fish of slow growth, not attaining full maturity till it is upward of four years old.

Distinguished from the burbot by the presence of several enlarged teeth in the lower jaw and on the vomer, the ling (*Molva vulgaris*) may be regarded merely

Ling and Rocklings

as a marine representative of that genus. The common ling, which generally measures from two to three feet in length, is a northern form, ranging from the coasts of Greenland and Iceland to those of Britain and other parts of Northern Europe. In this fish the upper jaw is the longer, but the reverse condition obtains in a second Scandinavian species, and also in a third from the Mediterranean, which are the only other representatives of the genus. The ling fishery is an important industry, large quantities of these fish being cured and dried. Belonging to the same group of the family as the ling, the rocklings (*Motella*) are readily distinguished by the reduction of the first of the two dorsal fins to a narrow-rayed fringe, with the first ray elongated, more or less completely received in a longitudinal groove. There is a band of teeth in the jaws, and another on the vomer, and all the species have barbels, not only on the chin, but likewise on the muzzle, the number of these appendages affording the readiest means of specific discrimination. They are all of small size, and while ranging over the same seas as the ling, likewise extend to those of Japan, the Cape, and New Zealand. The British representatives of the genus include the five-bearded rockling (*M. mustela*) with four upper barbels, the four-bearded rockling (*M. cimbria*), and the common three-bearded rockling (*M. tricirrhata*); the little fish commonly known as the mackerel midge, and formerly regarded as the representative of a distinct genus being only the young of the rocklings.

Brief mention may be made here of a fish from the Northern, Temperate, and Arctic seas, known as the torsk (*Brosmius brosme*), on account of its forming the sole representative of a group characterized by having only a single long dorsal and a shorter single anal fin, the caudal being distinct, the narrow pectorals formed of five rays, teeth present on the vomer and palatines, as well as in the jaws, and the chin furnished with a barbel. Attaining a length of a little over twenty inches the torsk is occasionally taken in the Firth of Forth, and is abundant round the Shetlands and Orkneys.

Sand Eels and their Allies—Family *Ophidiidæ*

In this rather small family, almost all the members of which are marine, the pelvic fins, if developed at all, are rudimentary; there is no separate anterior dorsal or anterior anal, and the caudal is generally confluent with the median fins. In form the body is more or less elongate, but it may be either naked or scaled. The dorsal fin occupies the greater portion of the back; the rudimentary pelvics are jugular in position; the gill openings are wide; and the gill membranes are not attached to the isthmus. While some of these fishes are deep-sea forms, others are littoral. The family may be divided into five subfamily groups.

Cave Fish

The most remarkable representatives of the first subfamily (in which pelvic fins, attached to the pectoral girdle, are always present) are two small fishes from the subterranean fresh waters of certain caves in Cuba, constituting the genus *Lucifuga*. They are totally blind, with the eyes rudimental and covered with skin, or wanting, and always live in perpetual darkness. The

cave fish are closely allied to certain small fishes from the tropical Atlantic and Indian Oceans forming the genus *Brotula*, and characterized by the elongate body being covered with minute scales, the moderate-sized eyes, the reduction of each pelvic fin to a single filament, of which the extremity may by split, the villiform teeth, and the presence of barbels on the muzzle; these barbels being reduced in the cave fish to small tubercles. With the exception of these cave fish, all the members of this family are marine forms; and it is very curious that among the latter there are two very rare species, respectively constituting the genera *Typhlonus* and *Aphyonus*, found at great depths in the southern oceans, which are are also completely blind, and apparently unprovided with any phosphorescent organs.

Snakefishes

The typical genus *Ophidium*, constituting, with an allied form, the second subfamily, has the pelvic fins replaced by a pair of barbel-like filaments; the elongated and compressed body being covered with very minute scales, while the eyes are medium, and the teeth small. The few species of this genus range over the Atlantic and Pacific. In the South American, South African, and Australasian seas there occur three much larger but nearly allied fishes, which have been referred to a second genus (*Genypterus*), on account of the outer row of teeth in the jaws, as well as those of the single palatine series, containing some enlarged tusks. These fish are of considerable commercial importance, and are known at the Cape as *klipvisch*, and in New Zealand as Cloudy bay cod, or ling.

Parasitic Fish

Some half-score species of very small eel-like fishes, scientifically known as *Fierasfer* and *Encheliophis*, and inhabiting the Mediterranean, Atlantic, and Indo-Pacific, have an especial interest on account of their curious mode of life. They constitute a subfamily, readily characterized by the total absence of pelvic fins and by the vent being situated at the throat; and are parasitic in other marine animals, frequenting the hollows in the bodies of jelly-fish, the breathing chambers of starfishes and sea cucumbers, and sometimes insinuating themselves between the layers of the mantle of pearl mussels or other bivalve mollusks. Occasionally they may become embedded in the substance of the shell of the pearl mussel by the deposition of pearly matter over their bodies; an instance of this peculiar mode of preservation being shown in the accompanying illustration.



PARASITIC FISH EMBEDDED IN A PEARL MUSSEL.
(From Günther, *Proc. Zool. Soc.*, 1886.)

The third subfamily is represented by the well-known sand eels or launces—of which a British species (*Ammodytes tobianus*) is figured in the illustration—so

Sand Eels

abundant on sandy shores in Europe and North America, as well as by an allied genus from Madras. While agreeing with the preceding group in the want of pelvic fins, they differ in having the vent situated far back in the body; and are further characterized by the great width of the gill openings, the gill membranes of opposite sides not being united. The lower jaw exceeds the upper in length, the dorsal fin occupies nearly the whole length of the back, and the anal is likewise elongated. The figured species, which is by far the commoner on the British coasts, generally measures from five to seven inches in length, whereas the greater sand eel (*A. lanceolatus*) may grow to a foot and a half. Sand eels feed on marine worms and very small fish; and when buried in the sand are captured in some parts of England by raking the sand with a long-pronged rake;



LESSER SAND EEL.
(Two-fifths natural size.)

their chief use being for bait. They are, however, by no means restricted to this kind of life, frequently swimming near the surface in large shoals, when they will at times suddenly descend to the bottom, where they bury themselves with surprising rapidity by the aid of the elongated horn-like extremity of the elongated lower jaw. During ebb tide, numbers remain buried at the depth of five or six inches in the sand till the next flood; and it is then that they are dug out with rakes or other implements. When swimming they are followed by shoals of mackerel and porpoises.

Conyrodus

The last group of the family is represented by *Conyrodus* of the Australian coasts, and *Haliophis* from the Red Sea, both of which differ from the sand eels by the narrower gill openings, and the union of the two gill membranes beneath the throat.

The Longtails — Family *Macruridæ*

The fourth family of the symmetrically-formed soft-finned fishes is typically represented by the genus *Macrurus*, as well as by several allied forms. These fish are characterized by the body ending in a long, compressed, and tapering tail, covered with spiny, keeled, or striated scales, and unprovided with an expanded fin.

There is a separate short first dorsal fin, followed, after a short interval, by a very long and low second dorsal, which is composed of very weak rays, and is continued to the end of the tail; the anal occupying a precisely similar position on the under surface, and the thoracic or jugular pelvic fins consisting of several rays. Dr. Günther writes that "this family, known a few years ago from a limited number of examples, representing a few species only, proves to be one which is distributed over all oceans, occurring in considerable variety and great abundance at depths of from one hundred and twenty to two thousand six hundred fathoms. They are, in fact, deep-sea gadoids, much resembling each other in the general shape of the body, but differing in the form of the snout, and in the structure of their scales. About forty species are known, many of which attain a length of three feet."

The Flatfishes — Family *PLEURONECTIDÆ*

Distinguished by the unsymmetrical conformation of the head and anterior region of the body in the adult, in consequence of which both eyes are brought on to one side of the body (in some cases the right, and in others the left), the flatfishes differ not only from all other members of their class, but likewise from all other vertebrates. The body is strongly compressed and flattened, with the side which is turned upward, and on which are situated the eyes, colored dark, while the opposite, or eyeless side is, as a rule, colorless. The bones of the head are unequally developed and unsymmetrical; and the dorsal and anal fins are of great length, and undivided, the former often extending forward so as to separate the blind from the eyed side of the head. In the most specialized forms the teeth and jaws are more developed on the lower or blind side than on the other, and there is no air bladder. Dr. Cunningham, who has paid special attention to the structure of these fishes, writes that "mere dissection of adult specimens show that the anomalous position of the eyes is due to a distortion of the facial region of the skull. The cranial region of the skull is but slightly altered, but the interorbital parts of the two frontal bones are bent away from their original position in the dorsal median line down to the side of the head, and they are also compressed into a thin plate. But the eyes have pretty nearly the same relation to the interorbital septum as in an ordinary fish. There is one eye on each side of the septum as usual. It is, in fact, the curious condition of the dorsal fin in the flatfish, even more than the mere distortion of the eyes, which makes it so different from the ordinary fish. If the fin terminated some distance behind the eyes, or if it was prolonged in the direction it ought to follow, that is along the line which divides the two frontal bones from one another, it would be plain at a glance which was the left side of the head and which the right. It would then be obvious that the left eye was still on the left side of the head, and the right eye on the right. But the dorsal fin does neither of these things. The external ethmoid bone belonging to the blind side is much enlarged, and sends back a process outside the eye belonging to that side to meet another process from the cranial region of the skull. Thus the eye which has migrated — the upper eye when the fish is held in a vertical plane — is inclosed in a

complete bony orbit, while the lower eye is merely bounded on its outer side by the jaw muscles. It is on this bony bridge, entirely foreign to the anatomy of an ordinary fish, that the dorsal fin supports itself in its advance towards the snout. Properly speaking, the left side of the face in a plaice, for instance, extends from the ventral edge, or chin, to the line between the eyes, but the dorsal fin in its anterior extension divides this side of the face into two parts.''

The pigment-bearing elements in the coloration of the dark side of flatfish are known as chromatophores; and while these are absent from the light side, the so-called silvery layer is present on both. Young flatfish, which are generally met with in the open sea, are transparent and perfectly symmetrical, with one eye on each side of the head, and swim in the vertical plane like ordinary fishes. That flatfishes have originated from symmetrical ancestors is quite evident, their individual metamorphosis indicating the manner in which the evolution took place. As to the inducing causes of this evolution and metamorphosis, there is still some difference of opinion; but as it is a subject which does not come within the province of this work, it need not be further alluded to. There are, however, certain experiments with regard to the normal absence of coloration on the under surface of these fish which are of sufficient interest to merit a brief notice. Knowing, as we do, that among plants absence of light leads to the deprivation of color, it was thought highly probable that the same might be the case with regard to flatfish, more especially since the absence of coloration in the olm among the Amphibians is clearly due to the same cause. To test this, flounders were kept in a tank, in which, by the help of a mirror, light was so introduced as to give to the fishes the unwonted experience of illumination ascending from below instead of coming down from above. The experiment was conducted for several months; some of the flounders died, in others no great effect was produced, but in some cases the white surface became marked over with pigment. This experiment demonstrates that the capacity for colorization existed in the skin, but that light was wanted to call it into action; and it may also be inferred that the incidence of light must in general be the reason why the upper surfaces of animals are more strongly pigmented than the lower. Occasionally what are known as ''double flatfish'' are met with, that is specimens in which both sides are colored, and one eye situated on the edge of the head; such monstrosities having been observed in the turbot, flounder, plaice, sole, etc. In one turbot the right eye was on the edge of the head, so that the dorsal fin, instead of extending, as usual, to the front of the head, was separated therefrom by a concavity, the right side being colored like the left, although somewhat less strongly. It has been thought that these ''double fish'' swam about in a vertical position, M. Giard stating that he has actually seen a turbot so doing. But Dr. Cunningham writes that there is ''no satisfactory evidence at present that the monstrous specimens, whose metamorphosis is permanently arrested, swim about, in whatever position, any more frequently, or rest on the ground less constantly than their normal brethren. I have under observation a living double specimen of the plaice; its eye is on the edge of the head, the dorsal fin terminates behind the eye, and the posterior three-fourths of the lower side are colored like the upper, the anterior fourth being white. This specimen, instead of showing a tendency to continue swimming in the water, cannot even be

induced to leave the bottom long enough to enable me to see whether it holds itself perfectly horizontal or not. I have never seen it leave the bottom of its own accord; it lies always buried in the sand up to its eyes, and, when disturbed, makes violent struggles to bury itself again."

When lying on the sandy bottom of the sea — and they prefer sandy to muddy situations — flatfish are almost indistinguishable from their inanimate surroundings, the spots with which the bodies of many of them are marked harmonizing exactly with the bright-colored pebbles strewing the sand. This resemblance is, perhaps, carried to the fullest extent in the flounder, as anyone who visits a large aquarium may ascertain for himself. Occasionally rising to the surface, they swim with an undulating lateral movement of the body, which is decidedly graceful; and they are found in shallow water, or at moderate depths. They are inhabitants of all seas, except those of the polar regions, and where the coast is precipitous and rocky; and although more numerous in the tropics, they attain their greatest development in point of size in the temperate regions. Many species, such as flounders, ascend rivers to a considerable distance; and a few have become accustomed to a fresh-water existence. As regards food, the whole of the species are exclusively carnivorous. In the fossil state the flatfish are but poorly represented, and it is probable that they were not evolved till the commencement of the Tertiary period; the earliest known forms being a turbot from the middle Eocene of Monte Bolca, while a fossil sole has been described from the Miocene of Würtemberg. As a food supply the flatfish are of especial value, not only on account of the large size, and abundance of their numerous representatives, but likewise from the excellent quality and flavor of the flesh of the majority of these. It is on the coasts of the temperate regions of the Northern Hemisphere that the pursuit of these fish is carried out with the greatest energy and success.

Psettodes

The least specialized member of the family (*Psettodes erumei*), which ranges from the Red Sea through the Indian Ocean to China, and also occurs on the west coast of Africa, belongs to a group in which the teeth and jaws are nearly equally developed on both sides, and is specially distinguished by the dorsal fin commencing on the nape of the neck, whereas in all the other forms it starts from above or in front of the eyes. In the Indian fish, which attains a length of about sixteen inches, the eyes are as frequently on the right side as on the left side, and the transposed one is situated nearly in the line of the dorsal fin. This species is a connecting link between the other members of the family and ordinary fishes, and is reported to swim at times in a vertical position.

Holibut

Having the jaws nearly equally developed on both sides, and the dorsal fin commencing above the eyes, the holibut (*Hippoglossus vulgaris*) is one of two species forming a genus characterized by the eyes being on the right side, and the teeth of the upper jaw arranged in a double series, those in the front of the upper and on the lower jaw being enlarged. The mouth is relatively wide. In color the holibut is dusky brown, frequently inclining to olive, on the dark side; the opposite side being white and smooth. It is the largest member of the family, ranging usually from three to six feet in length; one specimen with the latter length having a breadth of thirty inches, and a weight of one hundred and



FLAT FISH.

sixty-one pounds. It is stated, however, that an example taken in the early part of the last century off the Isle of Man was nearly double that weight. Holibut are found near all the northern coasts of Europe, as well as those of Kamchatka and California, generally frequenting banks at some distance from the shore, in water of from fifty to one hundred fathoms in depth, where they often associate in considerable numbers. The flesh is coarse, and of inferior flavor. This fish is shown in the upper figure of the colored plate.

Turbot, etc

In the genus typically represented by the turbot (*Rhombus maximus*) the dorsal fin commences on the muzzle in advance of the eyes; the eyes are on the left side; the mouth is wide; and the jaws are furnished with a single series of equal-sized villiform teeth, while there are also teeth on the vomer. Scales are either very small or wanting. The genus includes seven species, ranging over the North Atlantic and Mediterranean, but those on both sides of the Atlantic are different. The turbot, which attains a yard in length, and is by far the best food fish of its tribe, is exclusively European, and has the pelvic fins distinct from the anal, and no scales; the general color being grayish or brownish, sometimes spotted with a darker tint. On the other hand the brill (*Rh. lævis*), which is likewise European, is a smaller fish, of more oval shape, with the body and all the head, except the muzzle, covered with minute scales; its color being grayish brown, with reddish brown spots. Turbot commonly weigh from five to ten pounds, and occasionally reach twenty or even thirty, while considerably greater weights have been recorded. Another British representative of the genus is the Marysole (*Rh. aquosus*) which may be distinguished by its ciliated scales; while a fourth, known as Block's topknot (*Rh. punctatus*) differs from all the foregoing by having the pelvic fins confluent with the anal. The true topknot (*Phrynorhombus unimaculatus*), which is a small form not uncommon on the southern coasts of England, and abundant in the Mediterranean, is referred to a distinct genus on account of the absence of vomerine teeth. A turbot is shown in the central figure of the colored plate.

Plaice and Flounder

The plaice (*Pleuronectes platessa*) and flounder (*Pl. flesus*) of which examples are shown in the right lower corner of the colored plate are examples of a genus pertaining to a group characterized by the narrowness of the cleft of the mouth, and by the jaws and teeth being much more developed on the light than on the dark side. Unlike the turbot and its allies, where the upper is somewhat behind the lower, the two eyes are in the same transverse line, and generally situated on the right side. The dorsal fin commences above the eyes; the scales are minute or wanting; and there are no teeth on the palate, while those in the jaws are of medium size, and may be arranged in either a double or a single row. The genus, which is common to the Northern, Temperate, and Arctic seas of both Hemispheres, contains over a score of species, which may be divided into groups according to the form of the teeth, the number of rays in the dorsal fin, and the conformation of the lateral line. The plaice, which ranges from the French coasts to Iceland, and is represented by an allied form on this side of the Atlantic, belongs to a group with compressed, lanceolate, or truncate teeth, and no fewer than ninety dorsal rays; it has the brownish upper sur-

face marked with bright yellow spots. This species is exclusively marine, but the flounder is almost as much a fresh-water as a sea fish, ascending rivers to a considerable distance. Distinguished from the plaice by the dark mottlings on the brownish or brownish yellow skin of the upper surface, it belongs to a group in which the teeth are conical; the lateral line being very slightly curved in front, and the scales minute. Its distribution is practically the same as that of the plaice, and it is represented by an allied species in the Mediterranean.

Soles

In the plaice and its allies the pectoral fins are always well developed, but in the group to which the common sole (*Solea vulgaris*) belongs these may be wanting, while the upper eye is always somewhat in advance of the lower one, both being on the right side. As a genus the numerous species of soles (somewhere about forty in number) are characterized by the median fins being separate from one another, and the ctenoid scales; the dorsal fin commencing on the muzzle, and the lateral line being straight. The cleft of the mouth is very narrow, and twisted round to the left, or blind side; and it is on this side only that villiform teeth are developed in the jaws, the palate being toothless. With the exception of the lower south temperate zone, soles are distributed over all temperate and tropical coasts in localities suited to their habits; many of the species entering, or even dwelling permanently in fresh waters. The common sole, which is found on the coasts of the greater part of Europe, has both pectoral fins well developed, and the nostrils of the blind side very narrow; the general color being dark brown, with the tips of the pectoral fins blackish. Large specimens may weigh as much as five or six pounds, and a fish of nine pounds in weight is on record. Soles are taken by trawling; the best ground in England being along the south coast from Dover to Devonshire. The lemon sole (*S. aurantiaca*), which is a more southern form, ranging from the south of England to Portugal, and living in deeper water, is one of a group characterized by one of the notrils of the blind side being dilated and surrounded with a fringe of papillæ. It is smaller and wider than the common species, and orange or light brown in color, dotted over with numerous small brown spots. Other British species are the banded sole (*S. variegata*) and the dwarf sole (*S. minuta*), both belonging to a group characterized by the small size of the pectoral fins. The Mediterranean sole (*S. monochir*) is peculiar in lacking a pectoral fin on the blind side; while the Japanese sole (*S. japonica*) is one of two species in which both these fins are absent. The common species is shown in the left lower corner of the colored plate.

Blind Soles

On account of the rudimentary condition of their eyes we must not omit mention of the blind soles, which are divided into two genera, the one (*Soleotalpa*) characterized by the separation of the median fins, which are confluent in the other (*Apionichthys*); pectoral fins being wanting in both. Each genus is represented only by a single species; *Soleotalpa* coming from the West Indies, while the habitat of the other species appears to be unknown.

The Tube-bladdered Fishes — Suborder Physostomi

It has been already stated on p. 2702 that the whole of the four preceding subordinal groups of the bony fishes are regarded by Professor Cope as constituting but a single suborder (Physoclysti) characterized by the absence of a duct to the air bladder, the separation of the parietal bones of the skull by the supraoccipital, and by the pelvic fins being usually thoracic or jugular in position. The group to which we now come, including the whole of the remaining representatives of the existing bony fishes, differs from the above in that the air bladder, when present, has a duct communicating with the stomach or œsophagus, while the pelvic fins are always abdominal in position, and the parietal bones are usually in contact with each other. With regard to the constancy and importance of these characteristics of the present suborder, Professor Cope writes that the presence of the duct from the air bladder which characterizes it, "is always associated with an abdominal position of the pelvic fins and cycloid scales, and mostly with the presence of the precoracoid arch, the entrance of the maxillary bone into the border of the mouth, and the non-separation of the parietal bones by the supraoccipital. Yet none of these characteristics are precisely associated at the point of change in each, for there are Physostomous fishes with separated parietals and ctenoid scales (some *Cyprinodontidæ*), and there are Physoclysti with abdominal pelvic fins." In the present suborder, with the exception of the first in the dorsal and pectorals, which may be ossified into spines, all the fin rays are soft and jointed. Very different views obtain as to the best mode of arranging the families constituting the suborder, and a final classification is still a desideratum. By Professor Cope the families have been arranged in a number of sectional groups, mainly distinguished by the structure of the skeleton; and a modification of this arrangement is adopted here, although fewer groups are recognized. It is, however, impossible to enter here into the consideration of the osteological features by which these sections are distinguished, and we are accordingly compelled to rely mainly on external characteristics.

The Eels and their Allies — Families *Murænidæ*, *Symbranchidæ*, and *Gymnotidæ*

The whole of the members of these three families are characterized by the elongated, "eel-like" form of the body; but it is quite probable that this external similarity is due to parallelism in development, and that the three families have been independently derived from very different types of more normally formed fishes. The first family, which includes the true eels, murænas, and congers, is characterized by the normal structure of the upper jaw, which is formed in front by the premaxillæ (more or less confluent with the vomer and ethmoid) and laterally by the toothed maxillæ. The median fins, when present, are either confluent or separated by the projecting tail; the pectorals may or may not be developed; but the pelvic pair is invariably wanting. There are no accessory breathing organs; the

stomach has a blind appendage; the vent is generally situated far back, but may be near the pectoral fins; and the ovaries have no ducts. Externally the skin may be either completely naked, or may contain rudimental scales. In the skeleton the pectoral arch is unconnected with the skull, and attached to one of the earlier vertebræ. Eels are found in the fresh waters and seas of the greater part of the temperate and tropical regions; some living at abyssal depths in the ocean. The young of some forms are pelagic for a portion of their existence; and it is believed that a large number of the so-called Leptocephali (see p. 2690), or glass eels, are abnormal larvæ of this family. Geologically the family is a comparatively ancient one, true eels having been discovered in the Chalk of the Lebanon, as well as in the



MEDITERRANEAN MURÆNA.
(One-fifth natural size.)

Tertiaries of Europe. Congers referred to the existing genus *Ophichthys* have been described from the middle Eocene of Monte Bolca, and there is also an extinct genus from the latter deposits, and a second from the London Clay.

Murænas

The murænas are large marine eels remarkable for their bright spotted or mottled coloration, and taking their name from the species here figured (*Muræna helena*) which was so called by the ancient Romans. Belonging to a small section of the family characterized by the gill openings into the pharynx being in the form of narrow slits, they are specially distinguished by the median fins being well developed, and the total absence of pectorals. The skin is scaleless; the mouth is well furnished with teeth; and there are two nostrils on each side of the muzzle, the front pair being tubular; while the hinder ones may be either tube-like or mere flat openings. The murænas, of which there are more than eighty

species, are distributed over all tropical and temperate seas, and a few ascend tidal rivers. The majority of them are armed with formidable teeth — which frequently alter considerably with age — adapted for seizing the fish on which they feed. "Large specimens thus armed," writes Dr. Günther, "readily attack persons in and out of the water; and as some species attain a length of six or eight feet, they are justly feared by fishermen. The minority of species have obtuse and molar-like teeth, their food consisting chiefly of crustaceans and other hard-shelled animals. Most of the murænas are beautifully colored and spotted, some in a regular and constant manner, while in others the pattern varies in a most irregular fashion; they have quite the appearance of snakes." The figured species, which ranges from the Mediterranean to the Indian Ocean and Australia, has the ground color a rich brown, upon which are large yellowish spots, each dotted with small spots of brown. The finless murænas (*Gymnomuræna*), of which half a dozen species have been described from the Indian and Pacific Oceans, differ in the reduction of the fins to a rudiment near the end of the tail.

True Eels

The typical eels, familiar to all in the form of the common European species (*Anguilla vulgaris*), agree with the great majority of the family in having the gill openings into the pharynx as wide slits. The skin contains small scales embedded in its substance; the upper jaw does not project beyond the lower; the small teeth are arranged in bands; the narrow external gill openings are situated at the base of the well-developed pectoral fins, and the dorsal fin commences at a considerable distance behind the back of the head. Eels, of which there are numerous species, appear to be distributed throughout the fresh waters of the habitable portions of the globe, being reputed to be absent only from those of the Arctic regions, and probably also from cold elevated districts like Turkestan and Tibet. The common European eel is spread over the greater part of Europe and the Mediterranean area — although unknown in the Danube — and reappears in the United States. The so-called grig, or glat eel, characterized by its lighter color, broader head, and snout, and the more backward position of the front of the dorsal fin, has been generally regarded as a distinct species, although this is not admitted by Day. About a yard is a good size for an eel, although much longer specimens are on record. Few subjects have given rise to more discussion than the mode of propagation of eels, and as this must be noticed in some detail, we take the following extracts from a paper published a few years ago by the last-named observer. After mentioning the difficulties that took place in the identification of female eels, the author states that when this point was cleared up, naturalists became rather puzzled where to look for the male element, so the idea took root that these fishes might be hermaphrodites. It was observed that in addition to the frill-shaped band forming the undoubted ovaries, there was a second fatty band running along one side of the intestines, in which milt was erroneously stated to have been discovered. In 1873, however, an organ was discovered in an eel of sixteen inches in length, which was correctly identified with the male element, since which date numerous males, which are generally of smaller size than the females, have been recognized. "For the generation of eels it would seem, so far as we are at present aware, that the presence of salt water is a necessity, for it has been observed that when these

fish leave rivers and brackish waters for the sea, their reproductive organs have scarcely begun to develop. But their maturing in the sea must be rapid, because in five or six weeks they have arrived at a breeding condition. This rapidity of maturing in the breeding organs would seem to be the cause of extreme exhaustion. Consequently, after the breeding season is over, eels die, similarly to lampreys, and



EELS IN THE MUD.
(One-eighth natural size.)

several other piscine forms; and this furnishes the explanation why, subsequent to this period, old eels are not observed reascending rivers." After describing the appearances of the reproductive organs in fully-developed eels of both sexes, as well as those of sterile individuals, Day observes that "it becomes necessary to allude to the localities in which each of these forms may be found. Here, again, imagination seems to have mixed up fact with fiction, and it has been maintained that

should very young eels be introduced from the mouths of rivers into inland pieces of water, they invariably develop into fish of the female sex, as it was supposed males were never to be seen in fresh water. Whether such waters are really conducive to the destruction of young male eels, appears to be a subject requiring further elucidation. The female eels are those usually captured when descending toward the mouths of rivers during the autumn months, while such as are developing toward a breeding condition do not seem to feed at these periods. Males have been usually obtained from the mouths of rivers or in brackish waters; and Dr. Paul, having discovered that among elvers, or young eels, captured in such localities were males, ascertained (at least so he asserts) that when transported to fresh waters, they retained their masculine character, developing into adults. Some have been captured ten or twelve miles up rivers; but, although male eels undoubtedly ascend rivers, their proportionate number to that of females decreases in accordance to the distance from the sea. Sterile eels are found in fresh waters, and likewise in those which are brackish, where they may often be captured feeding, but these fish, of course, cannot increase in numbers unless they have access to the sea, and consequently above impassable barriers they die out, should no young be introduced. The migrations of these fishes may be said to be annually, adults descending seaward to breed, as they do in the Severn, about the month of September, although this migration in Norfolk is asserted to begin as early as July. There is likewise an up-stream migration of young eels, or elvers, in the earlier months of the year up to May or June, or even later; during this period the banks of the rivers being in places black with these migrating little fishes. These young eels have been observed to ascend flood gates of lochs, to creep up water pipes or drains; in short, mechanical difficulties scarcely obstruct them, and they will even make a circuit over a wet piece of ground in order to attain a desirable spot." In order to give some idea of the vast numbers of young eels that take part in these migrations, or, as they are popularly called "eel fares," it may be mentioned that upward of three tons of elvers were dispatched in a single day from the Gloucester district in the spring of 1886, and that it has been calculated that over fourteen thousand of these fish go to make a pound weight. In the previous year the annual consumption of eels was estimated at a minimum of 1,650 tons, with a total value of $632,450. It is almost superfluous to mention that eels pass the greater portion of their time when in fresh water buried in the mud, from which they issue forth at night to feed. During the cold of winter large masses of them are not unfrequently found tightly coiled together for the sake of mutual warmth. The largest species occur in the islands of the South Pacific and New Zealand, where they inhabit lakes; specimens from these regions having been recorded to measure from eight to ten feet in length.

Congers

Resembling the true eels in the presence of pectoral fins, in the tail being surrounded by the median fin, and the free tongue, the gigantic marine forms known as congers differ in being scaleless, in the deep cleft of the mouth, in the presence of a set of teeth on the outer sides of the jaw placed so close to one another as to form a cutting edge, and by the dorsal fin commencing at a point just behind the base of the pectorals. The common conger (*Conger*

vulgaris), which may grow to a length of eight feet, appears to be almost cosmopolitan in distribution, being as abundant in the seas of Tasmania as it is in British waters. Congers feed chiefly by night, and prey upon crustaceans, cuttles, and various kinds of fish, such as pilchards and herrings. Their favorite resorts are either hollows or crevices in the rocks, or sandy bottoms, in which they can bury themselves; and in such situations they are sometimes left by the ebbing tide. The flesh of these eels is of a highly gelatinous nature, and is said to be largely employed in soups. Three other species of the genus are known, one of which is abundant in the Indian Ocean.

Serpent Eels

Among the numerous other generic modifications of the family, we select for notice the serpent eels (*Ophichthys*) as an example of a group in which the extremity of the tail is free, the nostrils are situated at the extremity of the muzzle, and the tongue is fixed. Teeth are present on the vomers, those in the jaws being either obtuse, or pointed and arranged in a single series; and whereas small pectoral fins are present in some species, in others they are wanting. Serpent eels are represented by a great number of species, ranging over all tropical and subtropical seas, but none attaining any large size. The difference in the structure of the teeth of the various species may probably be taken as indicative of a difference in the nature of the food similar to that already recorded as obtaining among the murænas.

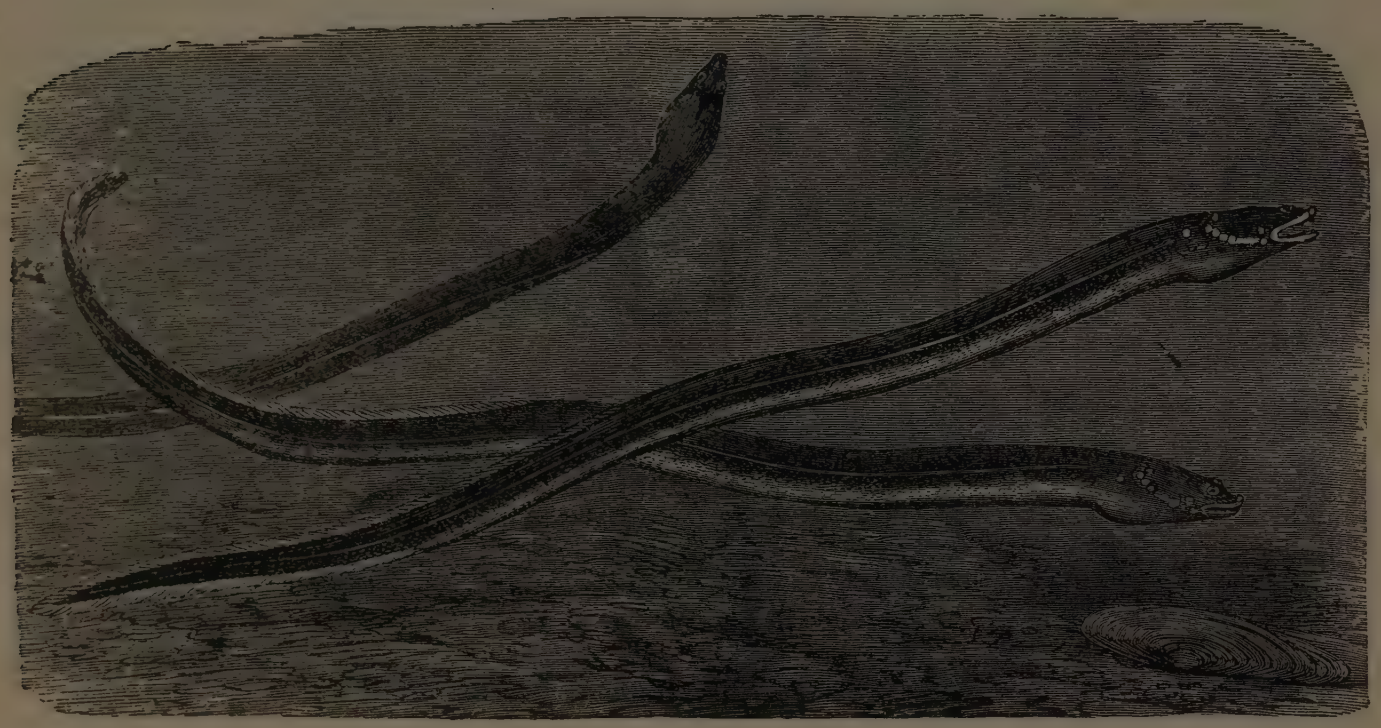
Deep-Sea Eels

Only a few words can be devoted to the deep-sea members of the family, which are represented by several genera. Among these are certain congers (*Synaphobranchus*) occurring in all oceans at depths of from three hundred and forty to two thousand fathoms, and characterized by the gill openings being united into a single longitudinal slit on the under surface of the body between the pectoral fins; the gape being very wide, the teeth small, and the body scaled. In these forms the muscular system is well developed; but in another genus (*Saccopharynx*) it is extremely feeble, except on the head, and the bones are soft and spongy. The head and gape are of immense size; the muzzle is short and flexible; the weak jaws are armed with long, slender, curved teeth, placed at intervals; and the gill openings are wide and situated on the lower part of the sides at some distance from the head, the narrow gills being free and exposed. The long and band-like tail ends in a long tapering filament, and the dorsal and anal fins are rudimental. As in the last genus, the stomach is capable of great distention, and specimens which had swallowed fish of many times their own weight have been found floating in the Atlantic with this organ dilated to its utmost. In a third type (*Nemichthys*), from depths between five hundred and two thousand fathoms in the Atlantic, the exceedingly elongate body is band shaped, with the tail tapering to a point, and the jaws produced into a long slender beak.

Single-Slit Eels

It has been already noticed that in one of the deep-sea eels the gill openings are confluent into a longitudinal slit on the under surface of the body; and a very similar condition characterizes the second family (*Symbranchidæ*) of eels, only in this case the slit is transverse. A better distinction is, however, afforded by the structure of the upper jaw, the margin of which in the present family is formed entirely by the premaxillæ, on the inner side

of which lie the maxillæ. The paired fins are rudimental, and the vertical ones wanting; while the scales, if present, are minute; and accessory breathing organs may be developed. An air bladder is wanting, the stomach has no blind appendage, and the ovaries are furnished with ducts; the vent being situated far behind the head. Whereas the majority of these eels inhabit fresh and brackish waters in tropical Asia and America, they are also represented in Australia, where one genus is marine. Of the fresh-water forms, the most remarkable is the amphibious eel (*Amphipnous cuchia*) of Bengal, in which there is an accessory breathing apparatus, the body is scaled, and the pectoral girdle is detached from the skull. There are only three gill arches with rudimentary laminæ, separated from one another by narrow slits; and the additional breathing organ takes the form of a lung-like sac on each side of the neck communicating with the gill chamber. Day states that



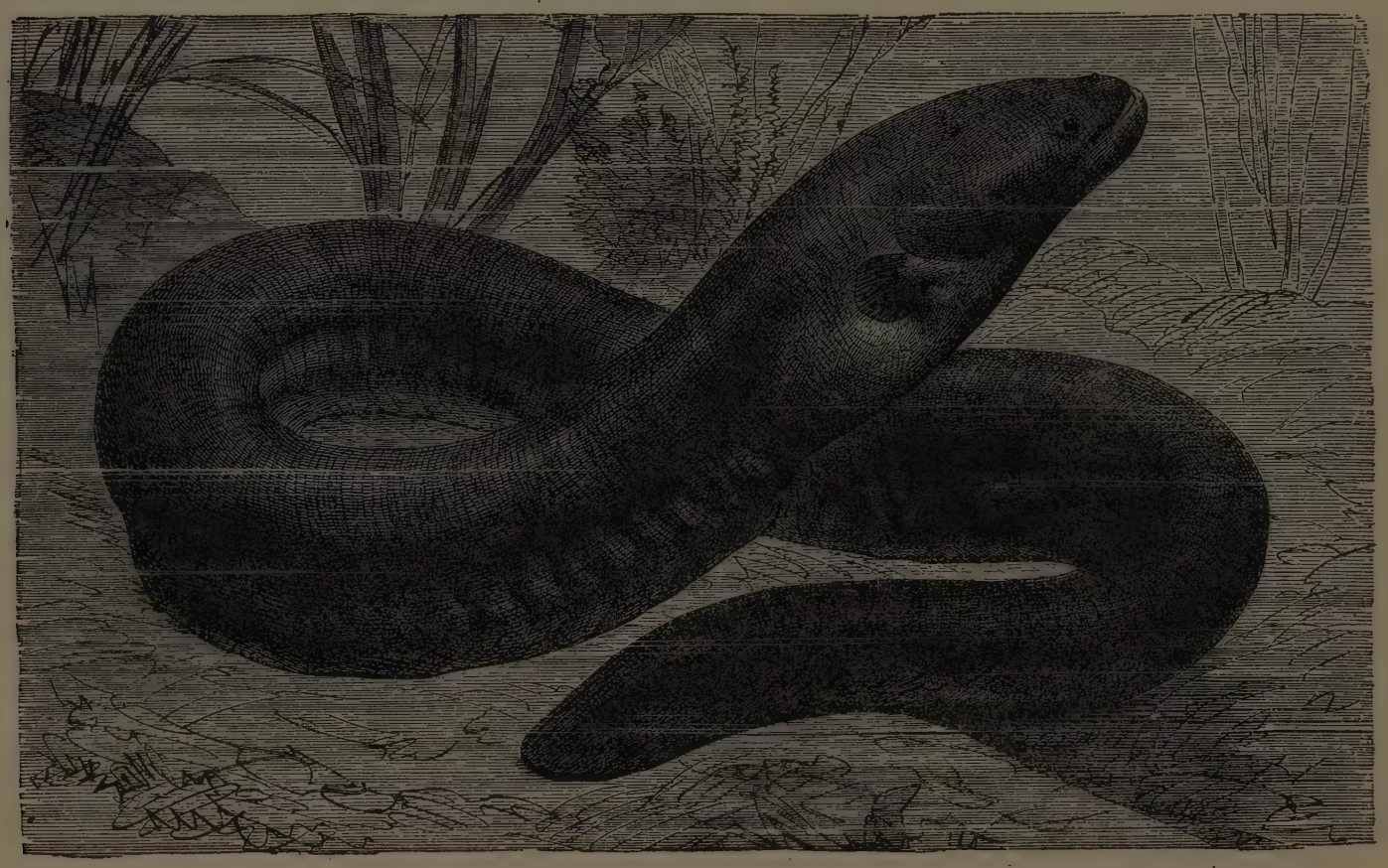
BENGAL SHORT-TAILED EEL.
(One-fifth natural size.)

"this amphibious fish, when kept in an aquarium, may be observed constantly rising to the surface for the purpose of respiring atmospheric air direct. It usually remains with the snout close to the surface, and in like manner lies in the grassy sides of ponds and stagnant pieces of water, so that without trouble it may obtain access to air." Indeed, the chief respiration of this fish is carried on by means of the two sacs on the sides of the neck, which can be inflated and emptied at will. In the other two fresh-water genera, one of which (*Monopterus*) is confined to the Oriental region, while the other (*Symbranchus*) has a distribution coextensive with that of the family, there is no additional breathing organ, the body is naked, and the pectoral girdle is attached to the skull. Whereas in the former of these genera the gills are rudimental, in the latter they are well developed; and, in the absence of an accessory apparatus, it seems strange how the one species with rudi-

mental gills manages to breathe at all. The Bengal short-tailed eel (*Symbranchus bengalensis*) has been selected to illustrate the external form of the members of this very remarkable family.

Electric Eel

Together with four other genera from the fresh waters of tropical America, the well-known electric eel (*Gymnotus electricus*) constitutes the third and last family of the group under consideration, the leading characteristics of which are as follows: The jaws are formed in the same manner as in the true eels, and the head is scaleless and without barbels. The dorsal fin is either totally wanting, or reduced to a fatty rudiment; the anal is extremely elongated; pelvics are wanting; and the caudal is likewise generally absent, the tail terminating in a point, which, when broken off, can be renewed in the same manner as in the



ELECTRIC EEL.
(One-sixth natural size.)

blindworms. The vent is situated in or near the throat; the gill openings are rather narrow; an air bladder is present; the stomach has a blind appendage; and the ovaries are provided with ducts. In the skeleton the pectoral girdle is attached to the skull. By Professor Cope the typical genus is considered to be to a certain extent intermediate between the last family and the eel-like representatives of the catfishes.

As a genus, the electric eel is characterized by the absence of the caudal and dorsal fins, by the anal extending to the extremity of the tail, the absence of scales, the single series of conical teeth, and the minute eyes. Abundant in the rivers and lagoons of certain parts of Brazil and the Guianas, the electric eel grows to a length of fully six feet, and is capable of giving a more powerful shock than any of the

other fishes endued with electric power. It will be unnecessary to give any description of the electric organs here; and it will accordingly suffice to mention that they form two pairs of longitudinal structures lying between the skin and the muscles; one pair being situated on the back of the tail, and the other along the sides of the base of the anal fin. That these organs are capable of giving shocks sufficient to kill other fish and small mammals is undoubted; but Dr. Günther considers that the description by Humboldt of the capture of electric eels by horses driven into water, in order to receive the shocks and thus exhaust the fishes, seems to be the result of the imagination of some person who related the supposed incident, or to rest on some isolated incident, since no recent travelers to the district have found evidence of the existence of the practice.

SECTION NEMATOGNATHI

The Catfishes or Sheathfishes — Family *SILURIDÆ*

Although represented only by a single European species, and that confined to the rivers to the eastward of the Rhine, the great family of catfishes is one of extreme importance in tropical and subtropical countries, its members being extremely abundant in the fresh waters and estuaries of the Oriental region, as they are in those of South America. An essential characteristic of the family is the invariable absence of scales, the skin being either smooth or covered with bony tubercles or plates; and this characteristic, together with the presence of the barbels from which they derive their popular title, will always serve to distinguish the catfishes from the other great fresh-water family of the carps. In the skull an essential feature is the absence of a subopercular element to the gill cover; the margin of the upper jaw is formed mainly by the premaxillæ, the maxillæ being more or less rudimental. A rayed dorsal fin may be absent, but the fatty dorsal is generally present; and when an air bladder is developed, it may be either free in the abdominal cavity or inclosed in bone, but always communicates with the ear by the intervention of the auditory ossicles, which are somewhat lenticular in form. The skull is characterized by the full ossification of its lateral region, the septum between the eyes being also bony; and in many instances the skull is prolonged backward by the development of a kind of bony helmet over the nape of the neck, formed by dermal ossifications overlying some of the bones of the pectoral girdle. Frequently this shield, as well as the hinder bones of the skull, are ornamented with a tuberculated sculpture. Many of these fishes have also a powerful spine at the front of the dorsal fin, which can be locked into a fixed, erect position by a rudimental spine acting as a kind of bolt at its base, and is itself articulated to the vertebræ, and also joined by a ring to a second spine, in a manner similar to that obtaining in the angler fish. To support this spine certain special modifications exist in the structure of the pectoral girdle. Some of the genera, such as the one represented by the eel-like catfish, have additional breathing organs; in this particular instance taking the form of a branched structure attached to the gills. On the other hand, in the

sac-gilled catfishes (*Saccobranchus*), there is a long sac running down the muscles of the back behind the proper gill chamber. Through this breathing sac blood is carried from and returned directly to the heart; and in consequence of this arrangement these fishes can remain alive for hours or even days apart from water, so that they are able to traverse spaces where aquatic respiration is impracticable. Among the Indian representatives of the family it is somewhat curious that whereas most of the forms dwelling far in the interior of the country near and in the hills have the air bladder ossified, this is not the case with those inhabiting the rivers of the plains and the sea. The majority of the catfishes are inhabitants of the fresh waters and estuaries of the tropical and subtropical regions of the globe; but, as we have seen, one species is found in those of Eastern Europe, while a considerable number enter the sea, although generally keeping near the coasts. They are found not only in rivers, but likewise in lagoons and marshes. Day writes that "they mostly prefer muddy to clear water, and the more developed the barbels the more these fishes appear to be adapted for an inland or muddy fresh-water residence. The wider and deeper the rivers, the more suited they are for the *Siluridæ*, consequently the larger forms are comparatively rare in the south of India, while they abound in the Indus, Jumna, and Ganges, as also in the Irawadi and other Burmese rivers." It may be added that they are equally common in the muddy waters of the La Plata river. "Owing to their usual resort," continues the same writer, "these fishes appear to employ their feelers in moving about in muddy places, and consequently have less use for their eyes than forms that reside in clear pieces of water. This is one reason why the size of the eye as compared with the length of the head is much greater in the young than in the adult. The eye, in fact, atrophies, instead of increasing in size in proportion with the remainder of the head. In some species the skin of the head passes over the eye without any trace of a free orbital margin. In the genus *Arius*, and some allied marine forms, the males appear to carry their ova in their mouths, perhaps until the young are produced. Many of these fishes are credited with causing poisonous wounds, and we frequently find such cases admitted into hospitals. The injuries may be divided into two classes, namely, those in which the wounds are of a distinctly venomous description, and those in which the jagged spines occasion intense inflammation, often of a dangerous character." The flesh of the catfishes is of an inferior quality, and generally eaten only by the lower classes. All the members of the family are very tenacious of life, and extremely difficult to kill. Geologically, catfishes date from the lower Eocene London Clay, where they are represented by the extinct *Bucklandium*, apparently allied to an existing African genus; while in the higher Eocene of the south of England there occur species referred to the existing genus *Arius*. An extinct genus has also been described from the Eocene of North America; and in the Eocene of Sumatra, as well as in the Pliocene of India, the fossil forms belong to existing genera, and some of those from the latter deposits even to species still inhabiting the same country. Numerically the catfishes form an exceedingly large family, the existing types constituting considerably over a hundred genera, many of which contain a multitude of species. In this work only a very few of the genera can be even mentioned, some of those selected including the largest members of the family.

Eel-Like Catfish

Clarias anguillaris is a well-known representative of the first subfamily, in which the long dorsal and anal fins extend nearly throughout the length of the trunk. It belongs to a minor group confined to Africa and the Oriental region, and characterized by the dorsal fin being either composed of weak rays throughout its length, or with its hinder portion modified into a fatty fin.

Wels

The wels (*Silurus glanis*), shown in the larger figure of the illustration on p. 2808, is the typical representative of the second subfamily, in which the rayed dorsal fin is but little developed, and if present at all occupies only the hinder region of the trunk; the fatty portion being small or wanting. The anal fin is not much shorter than the caudal region of the backbone, and the pelvic fins are behind or below the dorsal. In the wels and its congeners the short dorsal has no pungent spine; the fatty fin is wanting; there are two upper and two or four lower barbels; the head and body are naked; and the tail fin is rounded. The wels itself, which is confined to the European rivers eastward of the Rhine, has six barbels, of which the upper pair are considerably longer than the head, and commonly attains a length of from six to nine feet, although it occasionally grows to thirteen feet. In color the head, back, and edges of the fins are bluish black, the sides greenish black spotted with olive green, and the under parts reddish or yellowish white with blackish marblings. Frequenting rivers and lakes with muddy bottoms, the wels feed on fishes, frogs, and crustaceans, but will also seize and pull down ducks, geese, or other birds swimming on the surface. The spawning time is in the middle of summer, when these fish resort to the shallows in order to deposit their eggs on the stems and leaves of water plants.

Yarrell's Catfish, etc

Another gigantic species is Yarrell's catfish (*Bagarius yarrelli*) from the large rivers and estuaries of India and Java, which attains a length of fully six feet, and from its huge head and mouth is one of the ugliest fishes in existence. The only member of its genus, it belongs to a subfamily in which the rayed dorsal fin is short, and situated in the hinder part of the body in advance of the pelvics; and there is always a fatty fin, which may, however, be short; and the anal is shorter than the caudal region of the backbone. When nasal barbels are developed, they belong to the hinder nostrils. In the group of genera to which Yarrell's catfish belongs the front and hinder nostrils are placed near together, with a barbel between them; and in this particular form there are eight barbels, and the upper surface of the head is naked. This gigantic species is of especial interest on account of its fossilized remains occurring in the Pliocene deposits of the Siwalik hills in Northeastern India.

The well-known genus *Arius* from all the tropical regions of the world, belongs to another group of the same subfamily, in which the front and hinder nostrils are close together, but have no barbels, although the hinder pair are provided with a valve. The tropical American genus *Pimelodus* is the typical representative of a third group of the same subfamily, in which the two pairs of nostrils are equally devoid of barbels, but are placed at a considerable distance apart. The largest species is the leopard catfish or suravi (*P. pati*) from the rivers of

Argentina and Uruguay, growing to a length of six or seven feet, and having the yellowish skin marked with a number of black spots, like a hunting leopard. Somewhat curiously, this genus is represented by two outlying species from West Africa. The best-known representative of the fourth and last group of genera in this subfamily is the bayad (*Bagrus bayad*), of the Nile; the group being easily recognized by the circumstance that while the two pairs of nostrils are remote from one another, the hinder have barbels. Both species are confined to the Nile, but the allied *Chrysicthys* ranges over all tropical Africa, and *Macrones* and *Rita* are Oriental forms. In these forms the short dorsal fin has a pungent spine, and the head and neck are generally protected by a tuberculated bony shield.

Electric Catfishes

On account of the property from which they derive their name brief mention must be made of the electric catfishes (*Malapterurus*) of tropical Africa, belonging to a subfamily in which the rayed dorsal fin, when present, is short and confined to the hinder region of the body, while the pelvic fins are inserted behind. From their allies these fishes are distinguished by the total absence of the rayed dorsal, so that they have only a fatty dorsal immediately in front of the tail (which is rounded), and opposite the anal. The head and body are smooth, the pectoral fins have no spine, and there are six barbels. The species inhabiting the Nile grows to about four feet in length.

Mailed Catfishes

The only other members of the family, which space admits of mentioning, are the mailed catfishes (*Callichthys*, *Loricaria*, etc.), constituting a subfamily mainly confined to tropical and South America, although represented by a few Oriental forms. In all these fishes there is always a rather short rayed dorsal fin, beneath or in front of which the pelvics are generally inserted. The gill membranes are confluent with the skin of the isthmus, and the gill openings constricted to small slits. The pectoral and pelvic fins are placed horizontally; and the vent is in front of, or only slightly behind, the middle of the length of the body. Among these fishes the species of the genus *Callichthys*, which are confined to the rivers on the Atlantic side of South America, belong to a group characterized by the nearness of the two pairs of nostrils, between which there is generally a short flap, and by the expansion and reversion of the lower lip to form a broad flap more or less deeply notched in the middle. In the genus mentioned, the head is covered with bony plates, and the body incased in two rows of transversely elongated overlapping shields on each side; all the species being of small size. Like certain other South-American forms belonging to another subfamily, of which the members of the genus *Doras* are perhaps the best known, these mailed catfishes are in the habit of making nocturnal journeys during the hot season, when the pond they inhabit is about to dry up to another of greater capacity, and they likewise construct nests for their eggs. In the case of the genus last mentioned, these journeys may occupy several nights, during which the fish travel in large companies. As they have no special breathing sacs, they must apparently close their gill openings, and thus keep the gills moist. The nests which are made at the beginning of the rainy season, are formed of leaves, beneath which the eggs are deposited and watched over by both parents; the whole structure being sometimes placed in a hole on the margin of the river or pond. In the

armored catfish, forming the genus *Loricaria*, the body is remarkable for its elongated and slender form; while the head is depressed, with a more or less produced and spatulate snout, on the under surface of which the mouth is situated at a considerable distance from the extremity, its margins being surrounded by large folds, and each corner having a barbel. Both the dorsal and anal fins are short and elevated, and the entire head and body enveloped in a bony cuirass.

SECTION PLECTISPONDYLI

The Carp Tribe — Family *Cyprinidæ*

Adopting a modification of Professor Cope's classification, the eels and their allies may be regarded as forming one sectional group of the suborder, while the catfishes constitute a second by themselves. A third equivalent group will then be made by the carps, together with the under-mentioned family of the characinoids and certain allied forms. This third group — for which the name Plectispondyli has been proposed — while agreeing with the catfishes (forming the group Nematognathi) in having the first four vertebræ fused together and highly modified, differs in the presence of a subopercular bone. As in the last family, the margin of the upper jaw is formed by the premaxillæ, and the whole mouth is toothless, teeth being developed on the pharyngeal bones alone. While the head is invariably naked, the body is generally covered with scales, and although it may be scaleless it is never invested with bony plates. False gills may be developed, and, if so, are glandular. When an air bladder is present, it is always of large size; and it may be divided into two lateral moieties inclosed in an ossified capsule, or constricted into an anterior and posterior portion which are not thus protected. The numerous members of this family are fresh-water fish, confined to the Old World and North America, being quite unknown in the southern half of the New World, and also in Australia. Showing much less diversity of form and habits than the catfishes, the carp tribe are for the most part omnivorous, although a few of its members restrict themselves to a vegetable diet. Although some of them prefer muddy situations, where their barbels are probably of some assistance, the majority of the carps differ from the catfish in selecting clear waters for their haunts. The Indian forms seem to be more carnivorous than their European relatives, many of the larger kinds preying upon their smaller brethren. Geologically, the carps appear to be a comparatively modern group, the earliest known forms occurring in the Eocene of Sumatra; these being identified with the existing Oriental genera. Other fossil carps have been obtained from the North-American Eocene, and are assigned to extinct generic types; while in the Continental Miocene we find representatives of a number of the existing European genera, as well as of a few now mainly or exclusively Asiatic. On account of their more cleanly feeding habits the flesh of the carps is superior to that of the catfishes. The family is represented by over a hundred existing genera, arranged under two subfamilies.

True Carps

The common carp (*Cyprinus carpio*) claims our attention as the typical representative of the subfamily *Cyprininæ*, characterized by the air bladder (wanting in one Oriental genus) not being inclosed in bone, and divided into an anterior and posterior moiety. In the Oriental genus (*Homaloptera*) without an air bladder the number of barbels is six, but otherwise there are



GROUP OF CARP.

1. Carp; 2. Large-scaled variety of Carp; 3. Crucian Carp; 4. Barbel.
(One-fifth natural size.)

never more than four of these appendages, which may be reduced to a single pair, or be wanting.

Belonging to a group in which the anal is short and usually furnished with five or six branched rays, the true carp have the lateral line running along the middle of the tail, the dorsal fin placed opposite the pelvics, and containing a more

or less strongly serrated bony ray, and more than nine branched rays, while the pharyngeal teeth are arranged in three series, with those of the outermost one molar-like. The muzzle is rounded and blunt, with four barbels, and the rather narrow mouth at its extremity. The true carp form a small genus confined to the temperate parts of Europe and Asia, the common species being a native of the latter continent, and abundant in a wild state in China, where it has also long been domesticated. Thence it was introduced into Germany and Sweden, and subsequently into Britain — it is said early in the seventeenth century. The ordinary form is shown in the upper figure of the illustration on p. 2830; but there are many domesticated varieties, differing either in the form of the body or the size and arrangement of the scales. Among the latter, one of the most remarkable is the so-called *spiegel karpfen* (mirror carp), shown in the right-hand middle figure of the illustration. In this variety, which is found only in ponds, the scales are three or four times the normal size, and instead of covering the whole body are arranged in from one to three longitudinal rows, with bare skin between them. In Western Europe the carp has taken kindly to its new habitat, not unfrequently attaining as much as a yard in length, with a weight of twenty-five pounds, while very much larger specimens are on record. Preferring still waters, with a soft muddy bottom in which it grovels with its snout for food, the carp feeds on various vegetable substances, as well as on insects and other small aquatic invertebrates. When the surface of their haunts is locked in ice, carp lie deeply buried in holes in the mud, frequently consorting in numbers, and undergoing a partial hibernation, which is not broken till the returning warmth of spring. Their growth is extremely rapid, and their fecundity extraordinary, nearly three-quarters of a million eggs having been counted in the roe of a medium-sized specimen. They are capable of living a considerable time out of water, especially if they are moistened from time to time; and are known to live to a very great age. Carp will interbreed both with the Crucian and golden carp.

Crucian and Golden Carp

Easily distinguished by the absence of barbels, the Crucian carp (*Carassius vulgaris*) and the golden carp or goldfish (*C. auratus*) are the best-known representatives of another closely-allied genus; the former being a native of Central and Northern Europe, but also found in Italy and Siberia, while the home of the second is China and the warmer parts of Japan. Both are comparatively small species, and have been long domesticated; whereas, however, the Crucian carp always retain the original brownish color, the domesticated variety of the golden carp has assumed the well-known golden tinge from which it takes its name; an albino form being also known. Among the numerous varieties of this fish the most curious is the so-called telescope fish, shown in the right-hand figure of the illustration on p. 2782, taking its name from the prominence of the highly movable eyes, and likewise characterized by the great development of the caudal fin. In Europe goldfish thrive best in waters heated somewhat above the ordinary temperature, and they are accordingly frequently kept in engine ponds, where the water may have a temperature of some 80°, and in which they breed freely. The Crucian carp, shown on the left of the illustration on p. 2830, is confined to ponds and lakes, where it seeks the deepest parts.

Barbels

Represented by some two hundred species from the tropical and temperate regions of the Old World, the barbels are best known by the common European species (*Barbus vulgaris*), shown in the lower figure of the illustration on p. 2830, and the gigantic mahasir (*B. tor*) of India and Ceylon. Agreeing with the carp in the structure of the anal fin, and the position of the lateral line and the dorsal fin, they belong to a subgroup of genera in which there are generally not more than nine rays in the dorsal fin; the pharyngeal teeth being arranged in three rows, the greater part of the cheek not covered with bone, the anal scales not enlarged, and the eye unprovided with a fatty lid; while they are specially characterized by the arched mouth—which is devoid of internal folds—and by the presence of false gills. The anal fin is frequently tall, the lips are devoid of any horny covering, and the barbels, if present, may be either two or four in number. The scales may be either small or very large, and the body is frequently of a much more elongated form than in the true carp. While some species are not more than two inches in length, the mahasir, and some other kinds, may grow to at least six feet. Of the Indian forms, Day writes that those with four barbels (among which is the mahasir), "provided they are soberly colored, attain a large size; the brilliantly-colored forms are mostly residents in clear or rapid mountain streams, or rivers contiguous to hills, and generally small. A strong dorsal spine is usually (if not invariably) a sign that the species lives in the vicinity of high mountains, the streams of which it ascends to breed. An exception has, however, to be made of those forms with serrated dorsal spines, which are usually resident in the waters of the plains." The common barbel, which has four of the appendages from which it derives its name, not uncommonly grows to a length of two feet, with a weight of from eight to ten pounds, but may attain much larger dimensions.

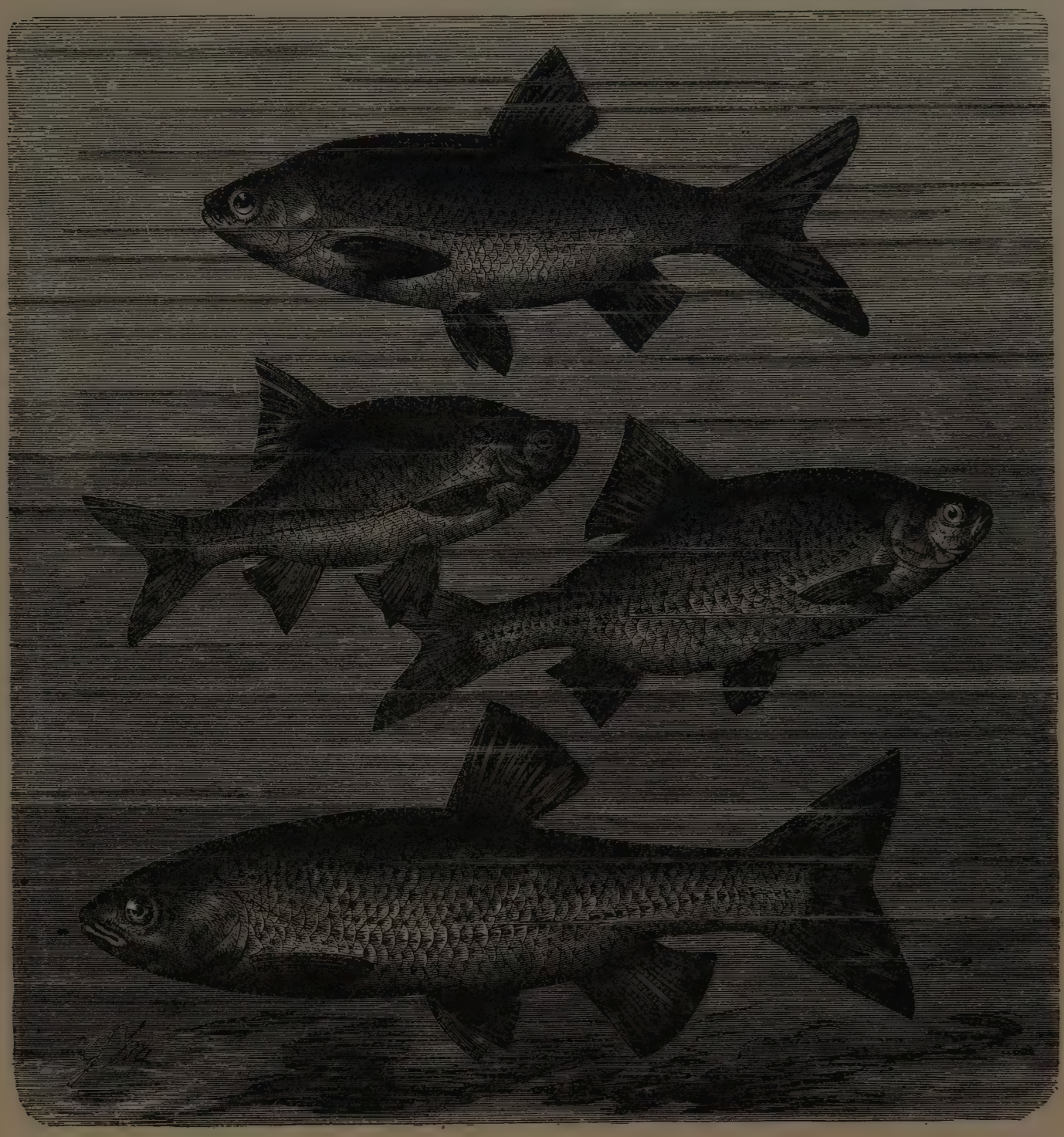
Gudgeon

Confining our attention mainly to the European representatives of the family, we have next to mention the gudgeons (*Gobio*) which may be distinguished from the foregoing by the pharyngeal teeth being arranged in a double or single series, the body being entirely covered with scales, and the muzzle having two small barbels, with the mouth inferior in position, and the premaxillary bones protractile. The scales are of moderate size, the short dorsal fin has no spine, and the intestine is remarkable for its shortness. These small fishes are represented only by two species, of which *G. fluviatilis* is British; and, like the barbels, they are purely animal feeding. The British species is shown in the lower figure of the illustration on p. 2836.

Whitefish

From the whole of the members of the family noticed above the so-called "whitefish" belong to a group of genera in which the anal fin is short or of medium length, with from eight to eleven branched rays, and not extending forward beneath the line of the dorsal; the lateral line, when complete, running nearly or quite in the middle of the tail. From certain allied forms they are distinguished by the short dorsal fin having no bony ray; and the pharyngeal teeth form a single or double series, the margin of the lower jaw is not cutting, and there are no barbels. As distinctive peculiarities of the whitefish may be mentioned the protractile premaxillary bones, the imbricating scales, and the smooth

outer surface of the pharyngeal teeth. The numerous representatives of the whitefish are distributed over the rivers of the North temperate zone, the New World forms somewhat exceeding in numbers those of the Old. Among the European representatives of the genus, the roach (*Leuciscus rutilus*), shown in the right-



GROUP OF WHITEFISH.
Ide, Rudd, Roach, and Chub.
(One-sixth natural size.)

hand middle figure of our illustration, agrees with several other species in having a single series of pharyngeal teeth, at least ten rays in the anal fin, and the dorsal nearly opposite the pelvic fins; its deep body being silvery, and the lower fins of the adult generally tinged with red. Its range is confined to Europe north of the

Alps. On the other hand, the chub (*L. cephalus*), shown in the lower figure of the illustration, may be selected as an example of a second group in which there are two series of pharyngeal teeth. This fish has a somewhat wider distribution than the last, extending southward into Italy and eastward into Asia; it is uniformly colored, with grayish margins to the scales. To the same group of the genus belongs the dace (*L. vulgaris*), with the same distribution as the roach, to which it presents a considerable external resemblance, although smaller and longer in form; its sides being silvery, but the fins not tinged with red. Roach and dace are commonly found in company, and have identical habits. The fish shown in the upper figure of our illustration is confined to the central and northern countries of the Continent, where it is known as the ide (*L. idus*), and is a uniformly-colored



TENCH.
(One-sixth natural size.)

species nearly allied to the last. It is of special interest on account of a golden-colored domesticated variety bred in Germany, and known as the orfe. Another member of the same group is the rudd or red eye (*L. erythopthalmus*), of which a specimen is represented in the left-hand middle figure of the illustration; this species, which ranges all over Europe and Asia, may be distinguished by its scarlet lower fins, the general hue of the scales being coppery. The familiar and diminutive minnow (*L. phoxinus*) differs from all the foregoing members of this group by the incomplete lateral line; its range being limited to Europe, although it is represented by an allied species in North America. The habits of all these familiar fish are too well known to need notice; but it may be mentioned that several of them will interbreed, as they will with species belonging to other genera of the family.

Tench Representing a genus by itself, the European tench (*Tinca vulgaris*) differs from the whitefish by the presence of a small pair of barbels to the mouth; the pharyngeal teeth forming a single series. The small scales are deeply imbedded in the thick skin; there is a complete lateral line; both the dorsal and anal fins are short; and the caudal, instead of having the markedly forked form characteristic of the roach and its allies, is but slightly emarginate. The terminally-situated mouth has its lips moderately developed. Whereas whitefish prefer clear running streams, the tench frequents ponds, lakes, and other more or less stagnant water; its color, which is sometimes bronzy golden, and in other cases olive green, with a more or less blackish tinge, is stated to vary with the purity or otherwise of the water in which it lives. Tench always keep near or in the mud, beneath which they entirely bury themselves during the colder months, after the fashion of so many members of the family. A good tench will weigh four pounds, but examples of five pounds, and even over, are not very uncommon. It is probably owing to the abundant supply of mucus secreted by the skin that the tench was considered to be endowed with healing powers. Tench are exceedingly prolific, and as they bear transport easily, are admirably adapted for stocking ponds.

Beaked Carp By this name may be distinguished a small genus, containing seven species, from Continental Europe and Western Asia, and differing from the two foregoing by the margin of the lower jaw forming a cutting edge, overlain with a brown horny layer; one of the species (*Chondrostoma nasus*) being represented in the lower figure of the illustration on p. 2839. These fishes are further characterized by the medium or small size of the scales, the termination of the lateral line in the middle of the deepest part of the tail, by the dorsal fin having not more than nine branched rays, and being situated opposite the root of the pelvics, and also by the rather elongate anal bearing ten or more rays. The mouth is inferior in position, and transverse; and there are no barbels. Commonly known in France as *le nez*, the figured species does not usually exceed eighteen inches in length, with a weight of about three pounds. It is generally found in deep water, where it feeds on various vegetable substances, but more especially on the green confervoid growth covering submerged stones, which is neatly mown off by a scythe-like action of the horny margin of the transverse lower lip.

Bitterling The small roach-like fish known as the bitterling (*Rhodeus amarus*), of which two examples are shown on the left side of the accompanying illustration, is the European representative of four genera of small carp mainly characteristic of Eastern Asia and Japan, and having the following distinctive features. The anal fin is of moderate length, and extends forward to below the line of the dorsal; the lateral line, when fully developed, runs on or near the middle of the tail; and there is but a single series of pharyngeal teeth. The bitterling, which belongs to a genus characterized by the incomplete lateral line, and the small size of the scales, is locally distributed in Central Europe, where it is not unfrequently found in hot springs. It is one of the smallest of European fishes, the females being generally about one and one-half inches in length, while the males do not exceed twice this size. The name is derived from the bitter taste of the flesh; and it is only perch and eels that will take this fish when used as a bait. In com-

mon with its allies, the bitterling is remarkable for the circumstance that in the breeding season the oviduct of the female is produced into an elongated tube, projecting a considerable distance beyond the surface of the body. This organ, which may be compared to the ovipositor of an insect, is introduced within the shells of fresh-water mussels, and the eggs are thus deposited in a situation where they will be protected from the attacks of enemies.



BITTERLING, BLEAK, AND GUDGEON.
(Natural size.)

Bream

The common European bream (*Abramis brama*), shown in the lower figure of the illustration on the next page, is the type of a large group of genera, characterized by the elongation of the anal fin, and by a portion or the whole of the abdomen being compressed so as to form a sharp edge. In the type genus the much compressed body is deep or oblong in form, with the scales of moderate size, and the lateral line running below the middle of the tail; the short dorsal fin, which is not furnished with a spine, being situated opposite the interval between the pelvic and anal fins. In both jaws the lips are simple, the upper being protractile, and generally longer than the lower, although occasionally the reverse

condition obtains. The pharyngeal teeth may be arranged in either a single or double series; and the scales do not extend across the sharp edge of the lower surface of the hinder part of the body. Distributed over Europe north of the Alps, portions of Western Asia, and North America, the breams are represented by about fifteen species, of which the common bream and the white bream (*A. blicea*) are



GROUP OF BREAM.
White Bream, Zope, Zarthe, and Common Bream.
(One-sixth natural size.)

found in Britain. The white bream, shown in the upper figure of our illustration, has the general color of the sides bluish white, without any trace of the golden yellow lustre, from the presence of which the common species is often termed the carp bream. They may also be distinguished by the iris of the eye in the latter being yellow, and in the former silvery white, tinged with pink. Yarrell writes that

"bream swim in shoals, feeding on worms, and other soft-bodied animals, with some vegetable substances; and if the water they inhabit suits them, which is generally the case, as they are hardy in their nature, they grow rapidly, and spawn in May. At this season one female is generally followed by three or four males, and they bear at this time a whitish tubercle on their scales, which causes them to feel rough to the hand." In some of the Irish lakes bream run to as much as twelve or fourteen pounds in weight; and as they are a greedy fish, great numbers can be taken by the aid of ground baiting. Of the other two species here figured, the zope (*A. ballerus*), forming the second figure from the top, is an inhabitant of Germany, Holland, and Sweden; while the zarthe (*A. vimba*), is found in the Danube, as well as in the rivers of North Germany, Sweden, and Russia. The latter species may be easily recognized by the keeled upper surface of the tail, and the projecting muzzle; while the zope is characterized by the great elongation of the anal fin, which commences opposite to the dorsal, and extends nearly to the tail, combined with the oblique direction of the cleft of the mouth.

Rapfen

By this name is known in Austria the typical representative (*Aspius rapax*) of a small genus of carps, containing four species from Eastern Europe and China, and somewhat intermediate in structural characteristics between the breams and the bleaks. Agreeing with the former in the shortness of the gill rakers, these fishes always have the lower jaw projecting considerably beyond the upper, which is but slightly protractile; the anal fin never has less than thirteen rays; and the sharp lower edge of the abdomen behind the pelvic fins is crossed by the scales. Common in Eastern and Northern Europe, although unknown in the British Islands, the rapfen is generally found in lakes or rivers flowing through level country, as it requires clear but tranquil waters. In color it is bluish black above, with the sides bluish white, and the under surface white; the dorsal and anal fins being blue, and the others tinged with red. In weight this fish does not exceed a dozen pounds, and in length never measures more than a yard.

Bleak

Especial interest attaches to the beautiful little fish known as the bleak (*Alburnus lucidus*), of which a figure is given on the right side of the illustration on p. 2836, on account of the use of the pearly matter from its scales in the manufacture of artificial pearls. Of bleak there are fifteen species, ranging over Europe and Western Asia; the common British species being found only to the north of the Alps, although represented by an allied form in Italy. From both the preceding genera these fish are distinguished by the slender and lanceolate form of the closely set gill rakers. The body is more or less elongate, with the scales of moderate size, and the lateral line running below the middle of the tail. The fins are generally similar to those of the last genus; and the lower jaw projects more or less beyond the upper, which is protractile. In the hinder part of the abdomen the scales do not extend across the sharp lower edge. Generally about four or five inches in length, and never exceeding seven, the common bleak is steel blue in color above, with silvery white sides and under surface, and the dorsal and caudal fins gray, the others being colorless. It is found in rivers, lakes, and ponds, preferring clear water; and in calm, warm weather swimming rapidly about near the surface in search of flies and other insects. During the

spawning season, which is in May and June, bleak collect in large shoals, which are preyed upon not only by perch, but likewise by gulls and terns.

Nearly allied to the bleak is a small fish (*Leucaspius delineatus*) from the rivers of Eastern and Southern Europe, distinguished by the extreme shortness of the lateral line, which scarcely extends beyond the extremities of the pectoral fins. The scales also are of a regular ovate form, without the distinct fan-like rays so characteristic of the bleak.



SICHEL, RAPFEN, AND BEAKED CARP.

Sichel

The last number of this great subfamily that we shall mention is the curious-looking fish (*Pelecus cultratus*) shown in the upper figure of the accompanying illustration, known in Germany as the sichel, and forming the sole representative of its genus. It is at once characterized by the whole of the abdominal surface of the oblong and compressed body forming a sharp cutting edge; the scales being small, and the lateral line making a sudden descent behind

the pectoral fin toward the lower surface. The cleft of the mouth is always peculiar in having a nearly perpendicular direction. The pectoral fins are unusually tall, and the dorsal is placed far back, and above the anal, which resembles that of the bream in its numerous rays. On the pharyngeal bones the teeth are arranged in a double series, and are strongly hooked. In profile this fish, which generally ranges from six inches to a foot in length, is remarkable for the straightness of the line of the back, and the convexity of its lower border. It is widely distributed in Eastern Europe, being common in the Black and Caspian seas, as well as in their affluent rivers. In form this fish makes a curious approach to the members of the herring tribe.



GIANT LOACH, COMMON LOACH, AND SPINY LOACH.
(One-half natural size.)

Loaches

With the small fishes known as loaches, of which there are three European genera, we come to the second subfamily (*Cobitinæ*) of the carp tribe, which is characterized by the air bladder being either partially or entirely inclosed in a bony capsule; false gills being always absent. In these fishes the body may be elongate, oblong, compressed, or cylindrical, but is never depressed; the muzzle and lips are fleshy; and the small, inferiorly-placed mouth is furnished with from six to twelve barbels. The median fins are spineless, the dorsal having a variable number of rays, but the short anal possessing but few, while the pelvic pair may be wanting; scales small, rudimental, or absent, and when present, cycloid,

and usually immersed in mucus; in one Oriental genus, developed upon the back and sides of the head. The loaches of this subfamily are confined to Europe and Asia; and while some of those from the former continent are partial to swift clear streams with a stony bottom, the Indian forms delight in muddy tanks, where they bury themselves in the mud. All are carnivorous; and, in spite of their small size, the European species are esteemed as food. The giant loach (*Misgurnus fossilis*), forming the central figure of our illustration, is the largest European member of the group, and belongs to a genus of four species, common to Europe and Asia north of the Himalayas. The genus is characterized by the elongate and compressed form of the body, the absence of an erectile spine near the eye and the presence of from ten to twelve barbels, four of which belong to the lower jaw; the dorsal fin being placed above the pelvic pair, and the caudal rounded. The European species, which grows to a length of ten inches, is found in stagnant waters in Southern and Eastern Germany, and Northwestern Asia; being replaced



ANGOLA LOACH.
(Natural size.)

by an allied form in China and Japan. The true loaches (*Nemachilus*), on the other hand, have six upper barbels, and none on the lower jaw. They are represented by some fifty species from Europe and temperate Asia; the common British loach (*N. barbatulus*), shown in the upper figure of the illustration, being found in clear streams all over Europe with the exception of Denmark and Scandinavia. The spiny loach (*Cobitis tænia*), shown in the lower corner of the illustration, is the typical representative of a third genus, distinguished from the last by the presence of a small, bifid, erectile spine below each eye. The figured species is locally and sparingly distributed in Britain, but more common on the continent. Certain Indian loaches formerly included in this genus are now regarded as distinct, the subfamily being represented by eight other genera in the same country.

African Loaches—Family *Kneriidæ*

Two small loach-like fishes from the fresh waters of tropical Africa, one of which (*Kneria congolensis*) is figured in the annexed illustration, alone represent a

family distinguished from the preceding by the absence of teeth on the pharyngeal bones, and by the elongated air bladder being undivided, barbels being wanting. While the figured species is from the west coast, the other (*K. spekei*) inhabits Central Africa.

The Characinoid Fishes—Family *Erythrinidæ*

As an example of a very extensive family of fresh-water fishes, confined to tropical America and Africa south of the Sahara, we select an American form known as the piraya (*Serrasalmo piraya*), since in our limited space it is quite impossible to deal with any of the others. It may be mentioned, in the first place, that these fishes are commonly known as the *Characinidæ*, but as there is no such



THE PIRAYA.
(One-fourth natural size.)

genus as the *Characinus*, it is obvious that this term cannot stand, and we have accordingly adopted another. According to Professor Cope's arrangement, these fishes belong to the same sectional group as the carp tribe, from which they may be distinguished by the brain case not being produced between the orbits, and likewise by the number of upper pharyngeal bones varying from four to one instead of being always two; a further point of difference occurring in the structure of the upper jaw, which is formed in front by the premaxillæ, and at the sides by the maxillæ. Like the carps, the body is scaled and the head naked; but barbels are invariably wanting, and the jaws may be either toothless, or furnished with a detention of a very powerful type. In most cases there is a small fatty fin behind the dorsal; the air bladder is always transversely divided into halves, and there are no false gills.

Unfortunately, there are no fossil forms to aid in the explanation of the peculiar geographical distribution of the family, which is very similar to that of the chromids; but there can be little doubt that the ancestral types originally inhabited the great land mass of the Northern Hemisphere, from whence they migrated southward to their present isolated distributional areas. It is, however, not a little remarkable that whereas in their migration to Africa they have been accompanied by members of the carp tribe, in tropical America they entirely take the place of that family. The numerous genera, none of which are common to the two Hemispheres, are ranged under eleven groups or subfamilies, the majority of which are confined to either the one or the other half of the distributional area, although a few have representatives of both. As regards their habits, some of these fishes are strictly carnivorous, while others are as exclusively vegetable feeders.

The figured species belongs to the last subfamily, which includes four exclusively American genera, represented by some forty species, and characterized by the somewhat elongated dorsal fin, behind which is a small fatty fin; by the gill membranes being free from the isthmus, and also by the distinct serration of the middle line of the under surface of the body.

On account of their large size, two other genera of these fishes, which have respectively received the names of *Hydrocyon* and *Cynodon*, must be mentioned; the former being from tropical Africa, and the latter from Brazil and the Guianas. They grow to the length of four feet, and are highly predacious; the subfamily to which they belong being characterized by the presence of a short dorsal and anal fin, the large conical teeth, the want of attachment between the gill membranes and the isthmus, and the approximation of the nostrils.

The Cyprinodonts — Family *Cyprinodontidæ*

The small fishes which, for want of an English title, we may designate cyprinodonts, bring us to the first family of another sectional group termed the Haplomi, which also includes the pikes. In addition to certain other structural features of the skeleton, this group is characterized by the first four vertebræ being separate and of normal form; while in the skull the parietal bones are separated by the supraoccipital, all the opercular bones are present, and the pharyngeals are distinct, the upper ones being directed forward, and three or four in number. As a family, the cyprinodonts are specially distinguished by the margin of the upper jaw being constituted solely by the premaxillæ, and the enlargement of the third upper pharyngeal bone. Externally they may be readily distinguished from the carps by the head being scaled as well as the body, and they have no barbels. Both jaws are toothed, and the pharyngeals are also furnished with teeth, which are heart shaped. There is no fatty fin, and the dorsal is situated in the hinder half of the body. The air bladder is simple, and the false gills are wanting. Inhabiting either fresh, brackish, or salt water, these fish are distributed over the south of Europe, Africa, Asia, and America; some being purely carnivorous, while others feed on the organic substances to be found in mud. Most of the forms are

viviparous; and the males, which are much inferior in size to the females, and, according to Dr. Günther, probably the smallest living fishes, frequently have the anal fin specially modified to aid in the reproductive process. As a rule, the fins are relatively larger in the males than in the females, and there is likewise some difference in the coloration of the two sexes. In a fossil state, remains of the typical genus occur in the Miocene strata of the Continent, which have also yielded others referred to an existing American genus; while the head of a species much larger than any now living has been described from the Pliocene of India, this specimen being figured in the accompanying illustration in order to show the scales on the head so characteristic of the family. Cyprinodonts are represented by about a score of genera, which may be divided into two subfamilies, according to the nature of the food. In the first of these, which includes the typical genus *Cyprinodon*, and has a distribution coextensive with that of the family, all the forms are carnivorous or insectivorous, and are characterized by the firm union of the two branches of the lower jaw in front, and likewise by the shortness, or slight convolution of the intestines. On the other hand, in the second subfamily, which is exclusively restricted to tropical America, the species seek their food in mud, and have the two branches of the lower jaw but loosely joined together, while the intestine is highly convoluted. It is in this group that the sexual differences are most strongly marked.



HEAD OF A FOSSIL CYPRINODONT, WITH ONE OF THE SCALES ENLARGED.

Double Eyes

As an example of the family we take a remarkable genus belonging to the first subfamily, represented by three species from tropical America, one of which (*Anableps tetropthalmus*) is shown in the following illustration. Having a broad and depressed head, with the region over the eyes much raised, the elongate body compressed in front and depressed behind, a protractile muzzle, and the cleft of the mouth horizontal and of moderate size, these fish are specially characterized by the structure of the eye, which is quite unique among vertebrates, and from which they derive their name. In each eye the integuments are divided into an upper and a lower moiety by a dark-colored transverse band in the outer layer; the pupil being likewise bisected in the same plane by means of a lobe projecting from each side of the iris. The scales are of small or moderate size; the dorsal and anal fins short, the latter being placed in advance of the line of the former, and in the male (which in this genus is larger than the female, modified into a long, thick, scaly organ, with an aperture at the end. These fishes are the largest existing members of the whole family, growing nearly to a foot in length. They are abundant in North Brazil and the Guianas, where they frequent mud banks on the coast and in the estuaries of the larger rivers; many of them being often left stranded by the retiring tide, where they progress

on the slime by a series of leaps. After birth the young are carried about by the female in a thin-skinned sac divided by a partition, until they are sufficiently advanced to take care of themselves. When swimming, these fishes frequently go on the surface with the eye half in and half out of the water; and it is in accordance with this habit that the eyes are divided, the upper portion being able to see in the air, while the lower is adapted for vision under water. That such is really the



FEMALE AND MALE DOUBLE EYE.
(One-third natural size.)

case, is proved by the structure of the lens of the eye. In terrestrial animals the lens is lenticular, that is to say of the shape of two watch glasses put edge to edge; whereas in ordinary fishes, which have to see in such a dense medium as water, the lens is spherical. Now in the double eye that portion of the organ of vision which is above the level of the water has the lens lenticular, while in that portion which is below the water the lens is spherical. In Brazil the flesh of these fish forms an article of consumption.

The Blindfish—Family *AMBLYOPSIDÆ*

The celebrated blindfish (*Amblyopsis spelœa*) from the Mammoth Cave in Kentucky, the Wyandotte Cave in Indiana, and the subterranean streams which appear to connect the waters of the two, is generally regarded as the typical representative of a family closely allied to the last. This fish, which does not exceed five inches in length, and breeds viviparously, closely resembles the genus *Cyprinodon* in that certain specimens (which have unnecessarily been separated as

Typhlichthys) lack the pelvic pair of fins. All traces of external eyes are wanting, and the skin is totally devoid of color. In order to enable the creature to find its way about in the dark subterranean waters of the limestone rocks of the Central United States, its head is provided with a large supply of organs of touch, arranged in a series of transverse ridges on each side; while its sense of hearing is also stated to be very highly developed. Professor Cope writes that if these fish "be not alarmed, they come to the surface to feed, and swim in full sight like white aquatic ghosts. They are then easily taken by the hand or net, if perfect silence is preserved, for they are unconscious of the presence of an enemy except through the medium of hearing. This sense is, however, evidently very acute, for at any noise they turn suddenly downward and hide beneath stones, etc., on the bottom. They must take much of heir food near the surface, as the life of the depths is apparently very sparse. This habit is rendered easy by the structure of the fish, for the mouth is



KENTUCKY BLINDFISH.
(Natural size.)

directed partly upward, and the head is very flat above, thus allowing the mouth to be at the surface. It thus takes food with less difficulty than other surface feeders, as the perch, where the mouth is terminal or even inferior; for these require a definite effort to elevate the mouth to the object floating on the surface." Nearly allied to that variety of the blindfish in which pelvic fins are absent is a small fish known as *Chologaster*, in which small external eyes are retained, and the body is colored; the front of the head being provided with a pair of horn-like appendages. These small fish were first known from three examples taken in the ditches of the South Carolina rice fields, but a fourth specimen was captured in a well in Tennessee in the year 1854. The retention of the eyes and their dark color indicates that these fishes have taken to a partially subterranean life more recently than the blindfish.

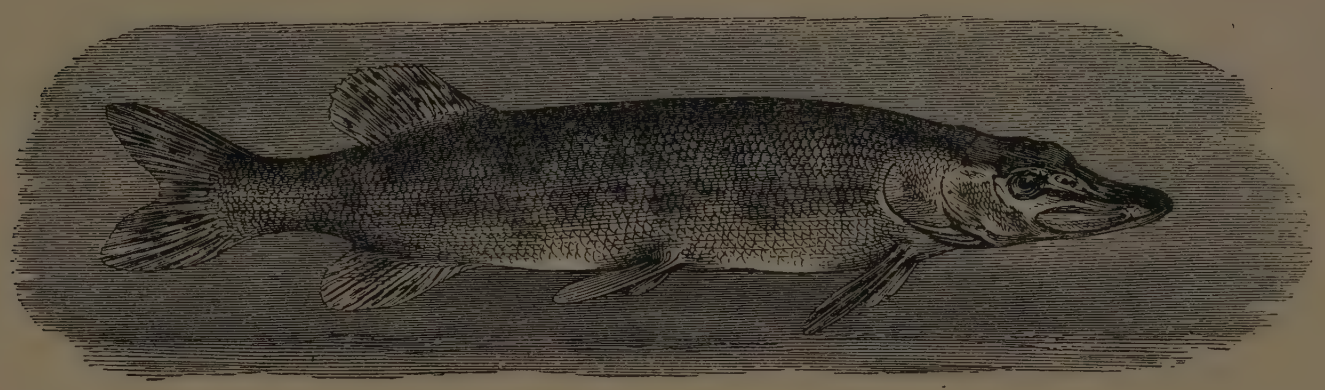
The Umbres — Family *Umbridæ*

A small fish from Austria-Hungary known as the umbre (*Umbra krameri*), together with a second (*U. limi*), locally distributed in the fresh waters of the United

States, indicate a family distinguished from the *Cyprinodontidæ* by the upper jaw margin being formed in front by the premaxillary bones and by the maxillary bones at the sides; the base of the skull being of simple structure in both families. Like the cyprinodonts, the umbres have the head and body scaled, and no barbels to the mouth. There is no fatty fin, and the dorsal is opposite the pelvics, or a little behind them, while the anal is short, and the caudal rounded. The stomach merely forms an expansion of the intestine; the air bladder is simple; and the false gills are hidden and glandular. The European species, which is known as the *hunds-fisch* in Germany, dwells in marshes and muddy pools, where it buries itself in the mud at the bottom. As in most cyprinodonts, the males are smaller and more slender than the females, scarcely reaching a couple of inches in length, whereas the latter grow to three or three and one-half inches.

The Pike — Family *ESOCIDÆ*

Such a familiar fish as the pike (*Esox lucius*) scarcely requires much in the way of description, but it is an important one as representing, with other members of the same genus, a family by itself. Agreeing with the umbres in the structure of the jaws, pike may be distinguished externally by the absence of scales on the head, and internally by the more complex structure of the base of the skull. The body is covered with cycloid scales; there are neither barbels nor a fatty fin; and the dorsal is situated in the caudal region of the vertebral column, in the position of the fatty fin of the salmon tribe. The stomach has no blind appendage, the false gills are glandular and concealed, and the gill opening is unusually wide. In the



COMMON PIKE.

upper jaw sickle-shaped teeth are borne by the premaxillæ, palatines, and vomer, the maxillæ being toothless, while the lower teeth are of variable shape. The long narrow body terminates in a forked caudal fin; and the long, broad, and depressed snout has the lower jaw exceeding the upper in length. Confined to the fresh waters of the temperate regions of the three northern continents, pike may be considered a western rather than an eastern type, seeing that whereas the common species has a range equivalent to that of the family, the whole of the other six species are confined to the United States. In Europe the pike inhabits all the Russian rivers, with the exception of those of the Crimea and Transcaucasia, and is

likewise found in Siberia. In Lapland it extends even beyond the limits of the birch, while to the south it is common in the Venetian lagoons. Growing very rapidly, the pike not uncommonly attains a length of forty-five or forty-six inches, with a weight of thirty-five or thirty-six pounds; and although fishes of much larger dimensions are on record, the accounts of these must be received with great caution. It is pretty well ascertained that fish of forty-five inches are not commonly more than about fifteen years old, and the stories of examples living for a century, or even more, appear to be legendary. Pike are among the most predaceous and greedy of all fresh-water fish, nothing coming amiss to their voracious appetites, since not only will they devour worms, leeches, frogs, trout, carp, and other fishes, but they pull under the young, and often even the adults, of all kinds of water birds, and have no objection to an occasional water vole. Their habit of lying like a log in the water (from which trait they probably derive their name), as well as the sudden rush they make after their prey, are well known to all; and the damage these fish do to trout streams is almost incredible. Pike are also great devourers of the smaller members of their own kind. Frequenting alike ponds, lakes, and rivers, pike in Ireland spawn as early as February, but in England a month or two later, while in some parts of the Continent the season lasts till May. Males, which are inferior in size to their consorts, are said to be more numerous than the latter; and it is not uncommon for a female in spawning time to be attended by three or four members of the opposite sex, who crowd around her as she lies quiet to deposit her eggs.

The African Beaked Fish — Family *Mormyridæ*

The very remarkable fish (*Mormyrus petersi*) shown in the upper figure of the illustration on page p. 2849, is the best known African representative of a large genus of fresh-water fishes confined to Africa, and constituting not only a family but likewise a distinct section, to which Professor Cope applies the name of Scyphophori. Having the narrow parietal bones of the skull distinct both from one another and from the supraoccipital, these fishes are especially distinguished by having each of the pterotics (which lie on each side of the parietals) large, funnel shaped, and inclosing a cavity expanding externally, and covered by a lid-like plate of bone. The anterior vertebræ are simple and unmodified; and a subopercular bone is present in the gill cover. Externally both the body and tail are covered with scales, but the head is naked, and the muzzle has no barbels. In the upper jaw the middle portion is formed by the united premaxillæ, and the sides by the maxillæ; the gill opening is reduced to a small slit; there are no false gills; and the air bladder is simple. A fatty fin is wanting; and whereas in the typical genus all the other fins are well developed, in the allied *Gymnarchus* (which is likewise exclusively African, and is sometimes regarded as the representative of a distinct family) the caudal, anal, and pelvic fins are wanting, the tail tapering to a point instead of terminating in a deeply forked fin. The beaked fishes are divided into groups according to the length of the dorsal fin and the form of the muzzle, the

figured species belonging to a group in which the dorsal fin is relatively short, scarcely exceeding the anal in length, while the muzzle is long and bent down. From its nearest allies the species in question is distinguished by the production of the extremity of the lower jaw into an elongated, conical, dependent, fleshy appendage, nearly equal in length to half the head. In color the skin is dark brown, relieved by two lighter cross-bands between the dorsal and anal fins. Other species have have the muzzle short and blunt; and whereas some grow to a length of between three and four feet, others are comparatively small fishes. No less than eleven species of this genus are found in the Nile; which, together with some of the West African rivers, is likewise the home of the single representative of the



PETERS' BEAKED FISH AND SLENDER PIKELET.
(One-third natural size.)

genus *Gymnarchus*. In form the later fish is eel-like; its jaws being armed with a series of incisor-like teeth, and its length reaching to upward of six feet. Both genera are furnished with a pair of organs lying on the two sides of the tail, which are stated to be transitional in character between ordinary muscle and a true electric organ; although, if this be correct, it is difficult to conceive what can be the object or use of such a structure. Each consists of an oblong capsule, divided by vertical partitions into a number of chambers filled with a gelatinous substance. One of the species (*M. oxyrhynchus*) from the Nile, is frequently depicted in the frescoes of the ancient Egyptians.

SECTION ISOSPONDYLI

The Feather Backs—Family *Notopteridæ*

According to the classification we are following, the whole of the remaining members of the tube-bladdered fishes form a group denominated Isospondyli, and characterized as follows: The parietal bones are completely separate; the symplectic bone, which is wanting in the group last treated of, is present; the anterior vertebræ are simple and unmodified, and both the upper and lower pharyngeal bones are separate. The group includes the least specialized of all the bony fishes, and those forming a transition to the ganoids. From the peculiar form of the dorsal fin certain fresh- and brackish-water fishes from West Africa and the



BORNEAN FEATHER BACK.
(One-third natural size.)

Oriental region, one of which (*Notopterus*) *borneensis* is shown in the above illustration, have received the not inappropriate name of feather backs. They constitute a family differing from all the others in this section by the tail being tapering and fringed inferiorly by a continuation of the anal fin, as well as by the presence of a cavity in the ring-like pterotic bone, the base of the skull being double. Both the body and the head are covered with small scales; barbels are wanting; the margin of the upper jaw is formed in front by the premaxillæ and at the sides by the maxillæ; and the opercular bones are incomplete. There is no fatty fin, and the dorsal, when present, is very short, and situated in the caudal region; the pelvic pair being rudimental or wanting. The air bladder is divided internally into several compartments and terminates at each end in a pair of narrow prolongations, of which the anterior ones are in communication with the organ of hearing. A further

peculiarity is that the spawn falls into the cavity of the abdomen previous to its exclusion. There are two Indian representatives of the genus, one of which grows to a couple of feet in length; a third is Bornean, and the other two are West African. An extinct species has been described from the Eocene of Sumatra.

The Southern Pikelets—Family *GALAXIIDÆ*

For want of a better name we may designate by the name of southern pikelets a genus of small fresh-water fishes from the Southern Hemisphere, one of which (*Galaxias attenuatus*) is represented in the lower figure of the illustration on p. 2849. Together with the members of the next family, these fishes are distinguished from the other genera of the present sectional group noticed here by having the base of the cranium simple, the tail being rounded or forked, and the pterotic bone devoid of a cavity in its interior. Externally these fishes may be recognized by the naked body and the absence of barbels; the fatty fin being absent, and the medium-sized dorsal opposite the anal. Internally the air bladder is large and simple; and the eggs, as in the last family, fall into the abdominal cavity. Represented by rather more than a dozen species, the largest of which seldom exceeds eight inches in length, these fish are of especial interest from a distributional point of view, since they occur in such isolated areas as New Zealand, New South Wales, Tasmania, and the southern extremity of South America. From their spotted bodies, the New-Zealand representatives of the genus were formerly known as trout by the colonists. An allied New-Zealand genus (*Neochanna*), represented by a single species, differs in the absence of pelvic fins; all the known specimens of this singular form having been found buried in burrows of clay or hard mud at a considerable distance from the water.

The Arapaimas—Family *OSTEOGLOSSIDÆ*

Agreeing with the last family in the conformation of the base of the skull, the large tropical fresh-water fishes, which may be collectively known as arapaimas (although this name properly belongs only to the Brazilian species here figured), are fully as interesting as the latter from their geographical distribution, which presents a curious general similarity to that of the existing lungfishes, although in the present instance one of the genera has a much wider range than either of the lungfishes. In confirmation of the northern origin of the present group, it is noteworthy that an arapaima exists in Sumatra, and also that an extinct genus (*Dapedoglossus*) occurs in the Eocene strata of the United States. From the preceding the more typical representatives of this family are structurally distinguished by the upper pharyngeal bones being three, instead of only two in number. Externally these fishes have the body covered with large, hard scales of a mosaic-like structure; the lateral line being formed by wide openings of the mucus canal; and the scaleless head nearly covered with roughened ossifications of the skin. The margin of the

upper jaw is formed both by the premaxillæ and maxillæ, the gill openings are wide, and false gills are wanting. The long dorsal closely resembles the anal fin, over which it is placed in the caudal region of the body; both coming very close to the tail fin, with which they may unite as an abnormality. In structure the air bladder may be either simple or divided into cells.



BRAZILIAN ARAPAIMA.
(One-twentieth natural size.)

Arapaima

The true arapaima (*Arapaima gigas*) of the larger rivers of Brazil and the Guianas, which is the sole representative of its genus, occupies the proud position of being the largest fresh-water bony fish, its length not unfrequently exceeding fifteen feet, while its weight may reach upward of four hundred pounds. As a genus, it is distinguished by the broad cleft of the mouth, in which the lower jaw is very prominent, and the absence of barbels, as well as by the rounded lower surface of the body, and the moderate length of the pectoral fins. In addition to an outer series of small conical teeth in the margins of the jaws, there are rows of rasp-like teeth not only on all the bones of the palate, but likewise on the tongue and hyoid bones. In spite of its enormous dimensions,

the arapaima is captured by the natives of Brazil with a hook and line; its flesh being highly esteemed as food, and in a salted condition largely exported. It is also taken by being struck with an arrow, to which a line is attached; and a graphic account of this method of hunting is given by Schomburgk. It appears that a party go out in a boat, and row about until a fish is sighted, when the bow and arrow are brought into requisition, and if the shot be successful, the monster is at length landed.

Barbelled Arapaimas

The four representatives of the typical genus *Osteoglossum* may be distinguished from the last by the presence of a pair of barbels to the lower jaw, the obliquity of the cleft of the mouth, the sharp lower surface of the body, and the greater length of the pectoral fins. Of the four species the first is American, and has the same distribution as the true arapaima, the second occurs in Sumatra and Borneo, while the other two are Australian. The two latter have, however, but a very local distribution, the one (*O. leichardti*) being confined to the rivers of Queensland, where it is known to the natives as the barramundi, and to the colonists as the Dawson river salmon; while the second (*O. jardinei*), which is distinguished by the absence of a spine to the anal fin, inhabits the rivers discharging into the gulf of Carpentaria. The flesh of both these species is highly esteemed as an article of food.

Small-Mouthed Arapaima

The third genus of the family, which includes only a single species (*Heterotis nilotica*), differs from both the foregoing in having the pharyngeal bones numerically the same as in the southern pikelets, on which account Professor Cope regards it as the type of a distinct family. Differing from the other two genera in the comparatively small size of the cleft of the mouth, and also in the approximate equality of the length of the jaws, this fish has no barbels, and only a single series of teeth in the jaws, teeth being also present on the pterygoid and hyoid bones, but wanting on the vomer and palatines. A further peculiarity is to be found in the presence of a peculiar spiral organ on the fourth gill arch; and the air bladder differs from that of the other members of the family in its cellular structure, while the stomach comprises a membranous and a muscular portion. The fish in question is found alike in the upper Nile and in the rivers of Western Africa. It grows to about two feet in length.

Moon Eye and Chisel Jaw — Families *Hyodontidæ* and *Pantodontidæ*

Each of the two fishes figured in the annexed illustration is the only representative not only of a genus, but likewise of a separate family; these families agreeing with all the remaining ones of the present section in having the pterotic bone normal, the base of the skull double, and four upper pharyngeal bones, all of which are distinct, and the third the largest and directed forward. In the first family the parietal bones are united, and there are two true tail vertebræ in front of the complex bone supporting the rays of the caudal fin.

Moon Eye

Externally, the moon eye (*Hyodon tergisus*), as the single representative of the first of the two families is popularly termed, has the body covered with cycloid scales, the head naked, and no barbels. The margin of the upper jaw is formed by the premaxillæ in front and the maxillæ at the sides, the latter bones being articulated to the former at the point of junction; and all the elements of the gill cover are present. There is no fatty fin, and the short dorsal is placed in the caudal region, above the fore part of the longer anal; the caudal fin being forked. The gill openings are wide; the stomach is horseshoe shaped, the



CHISEL JAW AND MOON EYE.
(One-third natural size.)

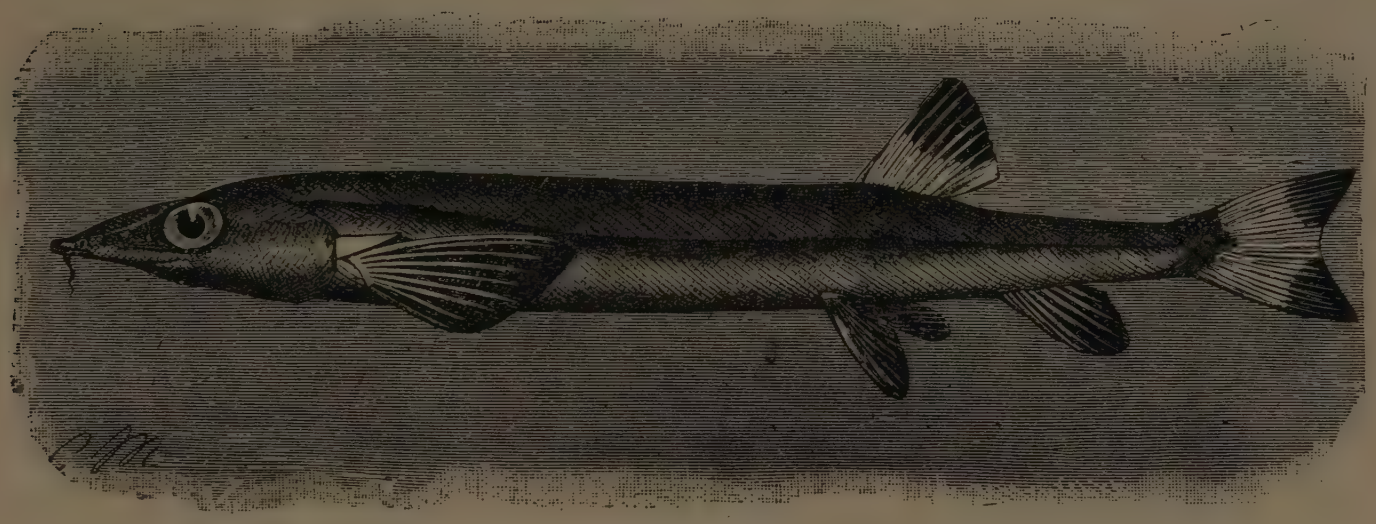
intestine short, and the air bladder simple; false gills being absent. In form the body is oblong and compressed, with a part of the lower surface forming a sharp edge; and the cleft of the mouth is somewhat oblique; all the bones of the palate bearing small teeth, and the edges of the tongue carrying a larger series. Before their exclusion, the eggs fall into the cavity of the abdomen. The moon eye, shown in the lower figure of the above illustration, grows to a length of from one foot to eighteen inches, and is confined to the fresh waters of North America, where it is abundant in the lakes and rivers of the western side of the continent.

Chisel Jaw

The small fish (*Pantodon buchholzi*) represented in the upper figure of the cut on p. 2854, was discovered not very many years ago in the rivers on the west coast of Africa, and takes its name from the strong dental armature of the jaws. Remarkably like a cyprinodont in external appearance, this fish has the body covered with relatively large scales, and the sides of the head with bony plates; the margin of the upper jaw being formed in front by the united premaxillæ, and at the sides by the maxillæ. The short dorsal fin is situated still further back than in the last genus, its front margin being considerably behind that of the rather longer anal; both the pectoral and pelvic fins are very tall, the rays of the latter forming isolated filaments, and the caudal is long and pointed, with some of its rays projecting. The muzzle is blunt, and the cleft of the mouth directed upward. In the gill cover there is only an opercular and a preopercular bone, the gill openings are wide, and the branchiostegal rays are numerous. False gills are absent; the air bladder is simple; and the ovaries of the female, and the corresponding organs of the opposite sex, are furnished with a duct.

The Beaked Salmon — Family *GONORHYNCHIDÆ*

A third fish of the present section, constituting a family by itself, is the so-called beaked salmon (*Gonorhynchus greyi*) from the seas of the Cape, Japan, and Australia. Agreeing with the two preceding families in the absence of a fatty fin this fish differs in having barbels to the mouth, while in the tail there is no true caudal vertebra. Both the head and body are completely covered with scales, of



BEAKED SALMON.
(One-third natural size)

which the free edges are spinose; and the margin of the upper jaw is formed entirely by the short premaxillæ, which are continued downward over the maxillæ. The short dorsal fin is situated far back on the body, above the pelvic pair, the still shorter anal having a more posterior position; and the tail fin is slightly forked. The gill openings are narrow, the air bladder is wanting, and the stomach simple.

Measuring from twelve to eighteen inches in length, this fish seems to be partly pelagic and partly littoral in its habits; being found in New Zealand, where it is known as the sand eel, in bays with a sandy bottom, while elsewhere it has been taken in the open sea. In New Zealand its flesh forms an article of food. The family is also represented by an extinct genus (*Notogoneus*) from the Eocene of the United States.

The Scopeloids — Family *Scopelidæ*

As an example of an important family of, for the most part, pelagic or deep-sea fishes, we select the so-called phosphorescent sardine, *Scopelus engraulis*, as being a member of the typical genus. The members of this family agree with the last in having the parietal bones united and no true tail vertebra, but they may be distinguished externally by the absence of barbels and the presence of a small fatty fin some distance behind the dorsal, and likewise by the want of spines on the scales, when the latter are present; some genera having the body scaled, while in others it is naked. The margin of the upper jaw is always constituted solely by the premaxillæ; the gill cover may be incompletely developed; the gill opening is wide; false gills are present; but an air bladder is wanting. The intestine is remarkable for its shortness; and the eggs are inclosed in the sacs of the ovaries, whence they are extruded by means of ducts. Containing a large number of existing genera, the family is likewise represented by several extinct types, the earliest of which dates from the Cretaceous of Istria.

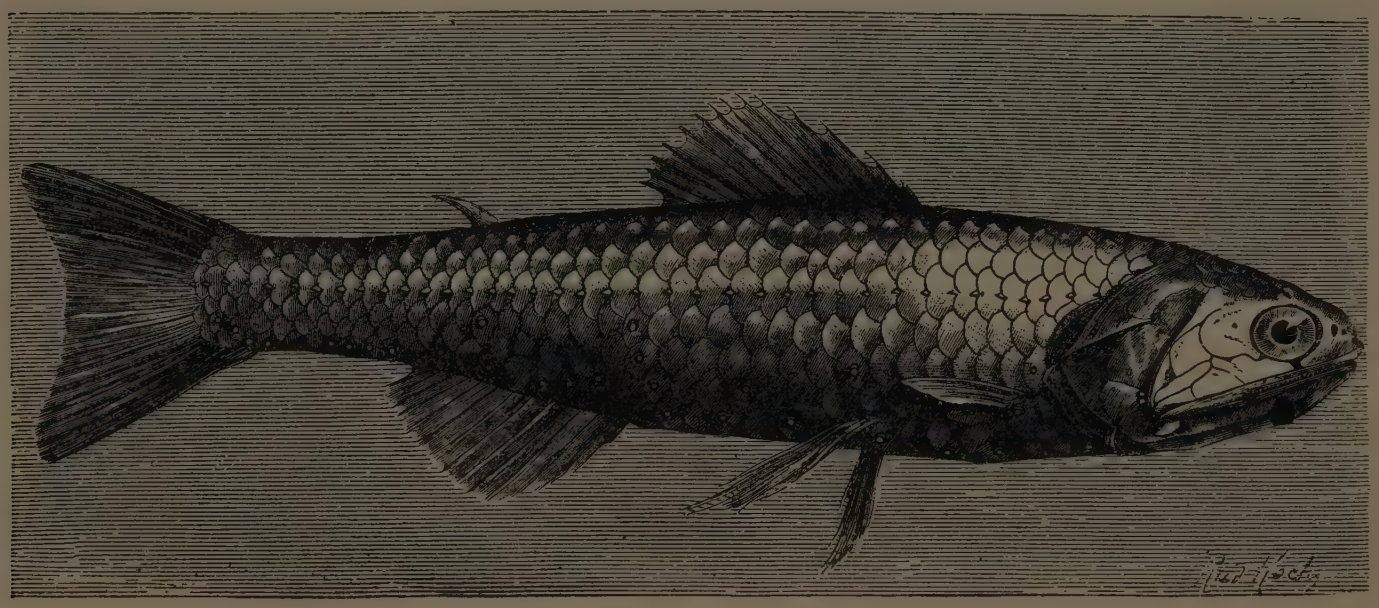
In the typical genus the body is oblong in form and more or less markedly compressed, with the investing scales of large size. Along the sides run series of phosphorescent spots; while similar grandular structures may in some species occur on the front of the body and on the back of the tail. The cleft of the mouth is unusually wide; the premaxillary bones being long, slender, and tapering, and the maxillæ well developed. The teeth are villiform, and the eye is relatively large. The pelvic fins are inserted just in front of or immediately below the line of the foremost rays of the dorsal (which is situated nearly in the middle of the length of the body), and are composed of eight rays; the fatty fin is very small; and the anal is generally long; and the caudal forked. There are from eight to ten rays in the branchiostegal membrane. Dr. Günther writes that "the fishes of this genus are small, of truly pelagic habits, and distributed over all the temperate and tropical seas; they are so numerous that the surface net, when used during a night of moderate weather, scarcely ever fails to inclose some specimens. They come to the surface at night only; during the day, and in very rough weather, they descend to depths where they are safe from sunlight or the agitation of the water. Some species never rise to the surface; indeed, scopeli have been brought up in the dredge from almost any depth to two thousand five hundred fathoms." Upward of thirty species of this genus are known, and there is also an allied genus (*Gymnoscopelus*) distinguished by the absence of scales.

Among several other remarkable forms of the family, we may especially notice a very curious fish (*Ipnops*) obtained at great depths during the voyage of the *Chal-*

lenger. Possessing an extremely-elongate and cylindrical body, covered with large, thin, deciduous scales, this fish has a depressed head and an elongate, broad, spatulate muzzle, of which the whole upper surface is occupied by a luminous or visual organ, divided longitudinally into halves, and representing the highly-modified eyes. The whole length of this strange fish does not exceed between five and six inches. Another deep-sea fish (*Plagyodus*) is noteworthy on account of its large dimensions, and the formidable armature of its mouth; the scaleless body being long and compressed, the snout much produced, and the teeth of the jaws and palate of very unequal size, some forming long and sharply-pointed tusks.

The Phosphorescent Scopeloids — Families *Sternoptychidæ* and *Stomateidæ*

More or less nearly allied to the scopeloids are two families of deep-sea or pelagic fishes usually bearing phosphorescent organs along the sides of the body; an example of each being represented in the following illustration.



PHOSPHORESCENT SARDINE.
(Natural size.)

Silvery Light Fish

The fish (*Photichthys argenteus*) shown in the upper figure of the illustration, is taken as our representative of the first of the two families, of which, in addition to the phosphorescent organs, the leading characteristics are as follows: The body may be either covered with thin deciduous scales, or entirely naked; barbels are wanting; and the fatty fin is either rudimental or of very minute size. Both the premaxillæ and maxillæ take a share in the formation of the margin of the upper jaw, and bear pointed teeth of variable length. The bones of the gill cover are not fully developed; the gill opening is of great width; false gills may or may not be developed; and, when present, the air bladder is of simple structure. The ovaries are furnished with ducts. Whereas

in the figured species the teeth are small, in the allied genus *Chauliodus* they are greatly elongated, and thus indicate highly predaceous habits on the part of their owner.

Hedgehog Mouths

The members of the second family of which the bearded hedgehog mouth (*Echiostoma barbatum*), shown in the lower figure of our illustration, is taken as an example, may be readily distinguished from the preceding by the presence of a long barbel to the hyoid; the skin being either naked or covered with exceedingly delicate scales, and the fatty fin (as in the figured specimen) frequently wanting. In other characteristics these fishes closely resemble those of the preceding family. When a fatty fin is present, as in the genus *Astronesthes*, the rayed dorsal is of considerable length, and placed in



SILVERY LIGHT FISH, AND BARBED HEDGEHOG MOUTH.
(One-half natural size.)

advance of the anal; but in the other genera both the anal and dorsal are short, and placed opposite to one another a short distance in advance of the forked caudal. In the genus represented by the figured species, the body is naked and the pectoral fins are filamentous; but in the allied *Stomias* there are exceedingly small scales which scarcely overlap one another. Occasionally met with floating in a helpless condition, these fishes have been dredged from depths of eighteen hundred fathoms; and it will not escape the notice of the reader that, although dwelling in total darkness, they, like most of their allies, have well-developed eyes. On this point, Monsieur Filhol writes that "the existence of eyes in fishes which we believe to live in a dark medium, seems at first sight impossible to understand. But this fact receives an explanation when we learn that the creatures furnished with these

organs are covered with a coating of lumious mucus, or bear phosphorescent plates. The phosphorescence with which the fishes of the ocean depths are endowed serves indeed both to guide them and to attract their prey, filling for them in the latter case the same office as a torch in the hand of a fisherman. This peculiarity has been long noticed in surface fishes which pursue their prey at night; Bennet, for instance, having described a shark which gives off a bright green phosphorescence from the lower surface of its body. On one occasion that zoologist brought into a room a freshly-caught specimen of this shark, upon which the whole chamber was illuminated with the light given off from its body. It is probable that the different species of sharks living at moderate depths, like the one described by Bennet, make use of their luminosity solely for the purpose of attracting their prey within reach. In most cases the origin of this light-giving mucus must be attributed to glandular organs distributed along the flanks and tail, on the head, and more rarely on the back. There exists, however, in certain fishes, which lack these glandular organs, an apparatus of a totally different nature for the emission of light; this apparatus consisting of a kind of biconvex transparent lens closing the front of a chamber filled with clear fluid. This cavity is carpeted by a blackish membrane, formed of hexagonal cells, thus recalling the retina of the eye, and is connected with certain nerves. Phosphorescent plates of this type may be situated either beneath the eyes, or on the sides of the body,'' one of the fishes thus furnished belonging to the family now under consideration, in which it forms the genus *Malacosteus*. A specimen of this fish captured before death had ensued was observed to emit a yellowish light from the uppermost plate beneath the eye, while that from the lower plate had a greenish tinge. In the genus *Stomias*, continues our author, ''the sides of the body present a double longitudinal series of phosphorescent plates, which emit light in such a manner as to cause the whole fish to be bathed in a brilliant luminous halo. This fish must, indeed, be a formidable creature to the other inhabitants of the ocean abysses; being in every way constructed and armed for strife, and its powerful teeth admirably fitted to seize and tear the flesh of the other fishes upon which it preys.'' In other species (*e.g. Eustomias*) the barbel is greatly lengthened, all the fins form long dentated filaments; the whole of these structures being apparently modified for the emission of phosphorescent light. In our figured species not only are there luminous dots down the sides of the body, but also larger plates beneath the eyes.

The Dorab — Family *Chirocentridæ*

With the fish represented in the illustration on p. 2860, which ranges from the Red Sea to the Malay Archipelago, and is commonly known in the East as the dorab (*Chirocentrus dorab*), we come to the first of what we may term the herring and salmon group, the more typical members of which differ from the preceding families of this section in having the parietal bones of the skull separated from one another by the intervention of the supraoccipital. In common with the herrings, this fish, which is the sole representative of its family, has but a single true tail

vertebra. Externally the body is covered with thin deciduous scales; barbels, and a fatty fin are alike lacking; but the elements of the gill covers are fully developed. The margin of the upper jaw is formed partly by the premaxillæ and partly by the maxillæ, which are firmly welded at their junction; the short dorsal fin is situated in the caudal region of the vertebral column above the much longer anal, the tail is deeply forked, the pelvic fins are minute, the lower surface of the body is sharp, the gill opening wide, and false gills wanting. The upward direction of the cleft of



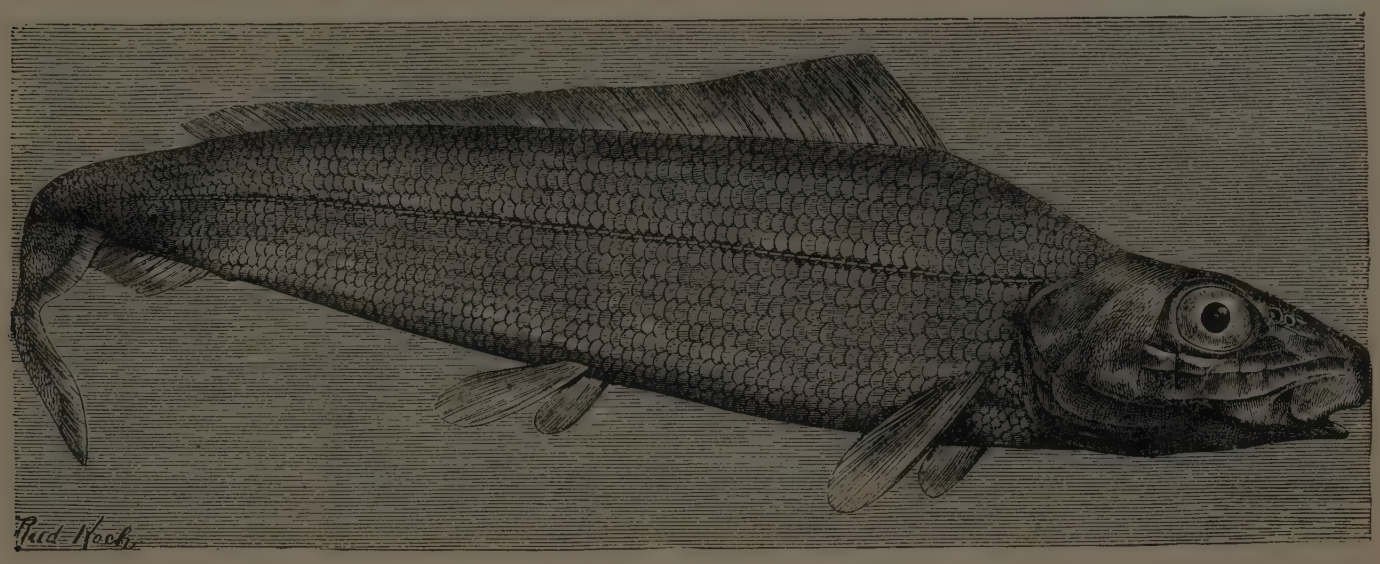
THE DORAB
(One-thirtieth natural size.)

the mouth, which is armed with formidable teeth, coupled with the elongation of the lower jaw, gives a rather peculiar expression to the head, and the eyes are remarkable for being covered with skin. The stomach is furnished with a blind appendage, the intestine is short, and the air bladder cellulated. As this fish attains a length of fully a dozen feet it is a sufficiently formidable monster, and when captured is said to bite viciously at every object within reach. Its flesh is of poor quality. It has been considered that the extinct *Chiromystus*, from the Eocene of Brazil, may belong to this family.

Long-finned Herring — Family *Bathythrissidæ*

Although its osteology has not apparently been described, we may place here the fish (*Bathythrissa dorsalis*) shown in the illustration on p. 2861, which is another of the numerous forms in the present section representing a family by itself. Having an oblong body, with a rounded under surface, invested with cycloid scales, the head naked and devoid of barbels, and no fatty fin, this fish may be at once recognized by the great length of the many-rayed dorsal fin, which occupies nearly the whole length of the back, and is situated in advance of the short anal.

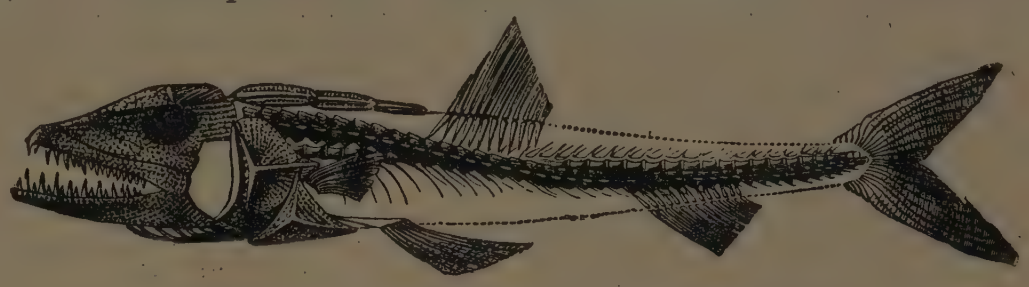
There is no air bladder, and very small eggs are produced by the ductless ovaries. This fish, which attains a length of two feet, has been obtained in Japanese waters at a depth of between three and four hundred fathoms.



LONG-FINNED HERRING.
(One-fourth natural size.)

The Extinct Saurodonts — Families *Enchgdontidæ*, *Saurocephalidæ*, etc.

Before proceeding to the consideration of the herrings, we may briefly refer to a group of more or less closely-allied extinct families, mainly characteristic of the Cretaceous period, but also represented in the lower Tertiaries. From the large size of their lanciform, reptile-like teeth, all the members of the group are collectively spoken of as the saurodont fishes.



SKELETON OF A SAURODONT FISH (*Eurypholis*).

The first family (*Dercetidæ*) is typified by the genus *Dercetis*, of the Chalk, and is characterized by the elongated form of the body, the large size of the teeth, which are implanted in sockets, and the presence of several rows of large triangular bony plates along the sides of the body; the muzzle being frequently produced into a beak, and the dorsal fin single. Nearly allied is the family (*Enchodontidæ*) represented by the widely-spread Cretaceous genera *Enchodus* and *Eurypholis;* these fishes having the body moderately compressed, and either naked or partially protected by bony plates, and the elongated upper jawbones armed (like those of the lower jaw) with small, immovably welded teeth. To a third family belongs the genus *Saurocephalus*, from the North American Cretaceous, which, together with the allied forms, has the body much compressed, the large upper jaw armed with powerful teeth, usually

set in sockets, and a single series of similar teeth in the lower jaw, the palatine bones being toothless. A peculiarity of the vertebræ of these fishes, with the exception of those of the neck, is the presence of two deep grooves and pits on their sides. Some of these fish attained huge dimensions; the American and Australian Cretaceous genus *Portheus* being distinguished by the presence of an enormous bony crest in the middle line of the skull.

The Herring Tribe — Family *Clupeidæ*

Second to none in their commercial importance, the herring tribe are remarkable for the enormous number of individuals by which several of the species are represented rather than for the multiplicity of the species themselves; this being probably one of the chief reasons for the great value of these fishes as a food supply. Although the existing representatives of the family may be readily distinguished from the salmonoids by the absence of a fatty fin, yet extinct forms indicate such an intimate connection between the two groups as to induce some naturalists to include both in a single family. Whatever may be the ultimate verdict on this point, in a work like the present, where we are mainly concerned with living types, it is obviously preferable to follow the ordinary system. While the typical representatives of the family have the parietal bones of the skull separated by the supraoccipital and but one true tail vertebra, in the genus *Elops* the parietals are in contact, and there are two caudal vertebræ. On this account it has been proposed to make the latter genus the type of a distinct family; a similar proposal having been made in the case of an analogous departure from the ordinary type among the salmonoids. In addition to the absence of the fatty fin, most herrings are characterized by the presence of small bony plates on the lower margin of the body. Externally the whole body is scaled, with the lateral line mostly wanting; while the head is generally naked, and the muzzle always without barbels. The under surface is more or less compressed, and generally so much so as to form a sharp edge which is usually serrated. In the gill cover the four elements are present, and the gill openings are in most cases very wide. Both premaxillæ and maxillæ enter into the formation of the margin of the upper jaw, but each of the latter bones is peculiar in being composed of three separate pieces. The single short dorsal fin has a small or moderate number of weak rays, and the anal may be many-rayed. The stomach is furnished with a blind sac; the air bladder is of more or less simple structure; and well-developed false gills are usually present. Distributed over all temperate and tropical seas, herrings are mainly littoral fishes, none of them being inhabitants of deep water, and none truly pelagic. Although the majority are marine, many of them will enter fresh water, and some live permanently therein, while it is probable that all can be acclimatized to such conditions. As might have been expected from their generalized structure, herrings are an ancient group, the typical genus dating from the period of the Chalk, while anchovies and other existing generic types are known from the Eocene. A number of more or less allied Cretaceous genera appear to connect the family very closely with the higher ganoids.

Typical Group

The common herring (*Clupea harengus*) belongs to a group of genera characterized by the equality in the length of the two jaws, the presence of free fatty lids to the eyes, and the serration of the lower border of the hinder part of the body; the typical herrings being distinguished from the allied genera by the anal fin being of moderate length, with less than thirty rays, and the serration of the under surface commencing from the chest or point of origin of the pectoral fins. Usually the scales are of moderate or large size, although they may be small; the cleft of the mouth is of medium width; and if teeth are present at all, they are rudimental and deciduous. In position the dorsal fin is opposite the anal,



SHAD, SPRATS, AND HERRING.
(The shad one-fifth, the others one-third natural size.)

and the caudal is deeply forked. Represented by some sixty species, the genus has a distribution coextensive with that of the family; but whereas the flesh of the majority of its representatives is of excellent quality, that of some tropical forms may acquire poisonous properties. In the case of such a well-known fish as the common herring it will be superfluous to give any description; but it may be mentioned that this species may be distinguished from its allies by the presence of a patch of small ovate teeth on the vomer. It has also the dorsal fin situated exactly midway between the extremity of the muzzle, and the longest ray of the caudal fin, and the pelvic fins are directly under the dorsal. Whitebait are for the most part the young of this species. Common to both sides of the cooler regions of the

Northern Atlantic, the herring ranges eastward to the seas on the north of Asia. Associating in shoals numbering millions of individuals, the herring feeds upon crustaceans, worms, insects, and the young and eggs of other fishes, as well as those of its own kind. "During the day," writes Mr. J. M. Mitchell, "the shoals are sometimes observable near the surface, and may be seen playing on the water, as the fishermen call it, making a ripple,—a dark roughness similar to what we may see at the beginning of a slight breeze, this being somewhat observable without the appearance of either whales or birds. The passing near or over them of a boat or ship makes them instantly dart off in every direction, leaving the appearance of long trails of light, if at night. We have been informed by fishermen of Newhaven that the herrings take considerable flights out of the sea; off Stonehaven, in the month of September, one of these men having seen a shoal, after the spawning season, rise up out of the water in a vast mass of many yards in extent, sparkling and flashing and flying several feet above the surface. . . . On some of the coasts, as on those of Norway the herring shoals are frequently accompanied or pursued by numbers of whales and aquatic birds, which are all occupied in preying on them. The large dark masses of the whales rising and blowing and throwing up great quantities of the herring into the air, sparkling and glittering in the clear winter day; the constant movements of the birds, with their shrill notes, actively engaged in seizing their easily-obtained food, vying with man in their attacks on the countless myriads of herrings, form a most wonderful sight. . . . When the herrings swim near the surface, if it is calm weather, the sound of their motion is distinctly heard at a small distance; and at night their motion, if rapid, causes a beautiful bright line from the phosphorescent quality of the skin; and it is also said, that when a great body of them swims near the surface, their presence is ascertained by a strong fishy smell." In another passage, after stating that the idea of fish migrating from the Arctic regions southward is purely erroneous, the same author observes that "from all circumstances known of the natural history of the herring, in regard to its visits on our own coasts and the coasts of other countries, it is reasonable to suppose that it inhabits the seas in the neighborhood of the coasts on which it spawns, and that it arrives at particular seasons near the coasts for the purpose of spawning, the shoals leaving the coasts immediately thereafter; and the early or late, distant or near, approach to the coast in different years, perhaps depends on the clear and warm, or dark and cold weather of the seasons, as well as upon the depth of water at the feeding and spawning grounds." Herrings have been kept in a brackish-water pond communicating with the Humber, where they became dwarfed in size.

The much smaller sprat (*C. sprattus*), so abundant on the Atlantic coasts of Europe, differs by the absence of vomerine teeth; while the shad (*C. finta*), shown in the upper figure of the illustration on p. 2863, may be distinguished by having one or more black blotches on the sides. In this species, which not only frequents the European coasts, but ascends rivers, and is abundant in the Nile, the bony gill rakers, of which there are from twenty-one to twenty-seven on the horizontal portion of the outer gill arch, are short and stout. On the other hand, in the similarly spotted allice shad (*C. alosa*) the gill rakers are very long and fine, and number

from sixty to eighty on the part mentioned. Both the shads are considerably larger than the herring. Whereas in both the herring and the sprat the opercular bone is smooth, in the pilchard or sardine (*C. pilchardus*) this part is marked by ridges radiating toward the subopercular. This species is abundant in the English Channel, the seas of Spain and Portugal, and the Mediterranean; Vigo bay being noted for its sardine fishery.

The following account of the sardine fishery is taken from the *Asian* newspaper: "Sardines are migratory in their habits, and the exact *locale* of their winter quarters, despite frequent research on the point, remains a mystery. In ordinary years it is the custom for the fish to make their first appearance on the coast of Africa about the end of March, then passing northward in large shoals, they follow the coast of Portugal, crossing the Bay of Biscay, till they strike the coasts of Vendée in the month of April or May. Before daybreak the fishing boats leave port to search for the shoals of sardines; indeed, many leave in the evening and anchor at sea. When a peculiar bubbling of the water reveals the fish, the nets are immediately thrown. Each net is from nine hundred to one thousand yards in length, about three yards in width, and black in color. On the upper part of the net are corkfloats, and on the lower part leaden sinkers to keep the net in an upright position. The oarsmen, generally two in number, row always either against the wind or the tide. One man casts the net as the boat advances, while another throws the *roque* into the water. This bait is an important feature of the sardine catch, as it is expensive, and fishermen often lose considerable quantities of it. It is made of the roe of codfish or mackerel mixed with clay, and costs from seven to seventeen dollars a barrel, and it is thrown into the water in small balls, which slowly dissolve and sink. At nightfall the boats return to port, where they sell their fish to the canners at prices varying according to the abundance of the catch and the size and freshness of the fish. Sales are made by the 'thousand,' but this term does not always indicate exactly a thousand sardines. For example, at Belle Isle one thousand two hundred and forty fish are supposed to make a thousand. Factories for preserving sardines are located at all the ports, for the fish spoil easily and cannot bear transportation. The fishermen convey the sardines to the factories in baskets. The process of canning is as follows: The sardines are spread on boards and salted, and the heads removed. They are then thrown into brine, where they remain half an hour. They are next washed in clean water and dried on screens. This work is done almost entirely by the wives and children of the fishermen, their united wages during the season enabling the family to subsist during the following winter. After the fish have been thoroughly dried they are cooked by dipping them for a few minutes in oil heated to 212° F. They are again drained and handed over to workmen, who pack them in small tin boxes, which are filled with pure olive oil and then soldered. The oil used is imported from the province of Bari, Italy. The boxes are next thrown into hot water, where they remain for two or three hours, according to the size of the boxes. When withdrawn, the boxes are first cooled, then rubbed with sawdust to cleanse and polish them, and packed in wooden cases of one hundred boxes for export; during their immersion in the boiling water oil will escape from all boxes not properly

soldered, and in such cases the loss is sustained by the solderer, but so skillful are those in the craft that a good workman rarely misses more than two or three boxes per hundred. Periodically the fish entirely disappear for a season or so from the coasts of Spain, France, and Italy.''

Fresh-Water Herrings

Especial interest attaches to the Australian fresh-water herrings (*Diplomystus*), which differ from the typical genus in having a series of bony plates similar to those on the lower surface between the back of the head and the dorsal fin, since a similar type of fish has been long known in a fossil state, having been obtained from the Cretaceous rocks of Brazil and Syria, and the Lower Tertiary of the United States and Britain. The persistence at the present day of this ancient type of herring in the fresh waters of Australia is an instance of the survival of primitive forms of life in that region.

Anchovies

The common anchovy of the Mediterranean (*Engraulis encrassicholus*) is the typical representative of a second widely-spread genus, with over forty species, differing from the last by the more or less nearly conical muzzle projecting beyond the lower jaw, and also by the eyes being covered with skin; while the cleft of the mouth is deep, and the tail fin forked. In most cases each side of the body is ornamented with a broad longitudinal silvery stripe. The common anchovy is met with off the southwestern coasts of England, but wanders still further to the north, and serves to supply the markets of the world. Some species have the rays of the pectoral fins produced, and thus lead on to the allied Oriental genus *Coilia*, in which the foremost rays of these fins are filamentous, and the exceedingly long anal fin extends backward to join the caudal.

Elops

A very distinct group, which, as already mentioned, is regarded by some as a distinct family, is typically represented by the two species of the tropical and subtropical genus *Elops*. In addition to the characters of the skull noticed on p. 2862, these fish have the lower jaw longer, a thin plate of bone extending backward from the point of union of the two branches of the lower jaw, and the whole under surface of the body smooth and rounded. The common species grows to a yard in length. An allied type (*Rhacholepis*) occurs in the Cretaceous rocks of Brazil.

Slender Scales

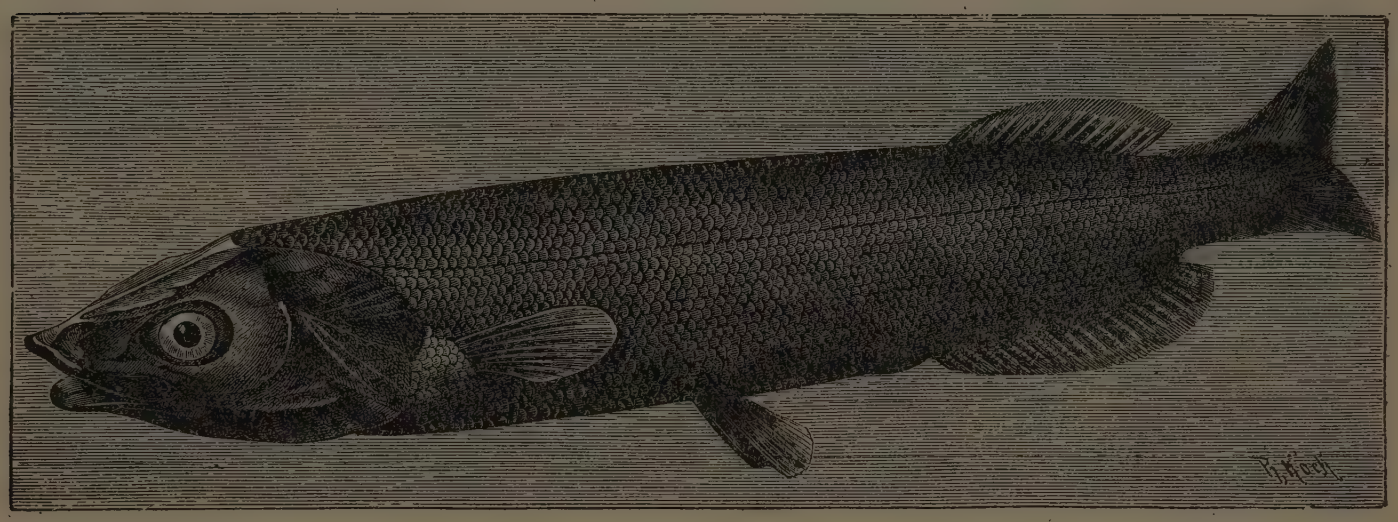
The earliest allies of the herring tribe seem to be the extinct slender scales (*Leptolepididæ*), of which there are a considerable number of species, ranging throughout the Jurassic period. In the typical *Leptolepis* the dorsal fin is placed immediately over the pelvic pair, but in the nearly-allied *Thrissops* it is over the anal. Although there are a number of other extinct generic types, more or less closely related to herrings, it is impossible to enter into their consideration here, and we accordingly pass on to

The Smooth Heads and Southern Salmon.

Families *ALEPOCEPHALIDÆ* and *HAPLOCHITONIDÆ*

Smooth Heads

The first of these two families is typically represented by the genus *Alepocephalus*, of which a species (*A. niger*) is shown in the annexed illustration. While agreeing with the typical salmonoids in the structure of the skull and the presence of two true tail vertebræ, as well as in other features, these fish may be distinguished by the absence of the fatty fin. Whereas barbels are invariably absent, and the head is always naked, the body may be either scaled or bare. Both premaxillæ and maxillæ enter into the formation of the margin of the upper jaw, the former occupying the upper front edge of the latter. All the elements of the gill cover are present; the dorsal fin is situated opposite the anal in the caudal region; the gill openings are very wide; false gills are present; the air blad-



BLACK SMOOTH HEAD.
(One-third natural size.)

der is wanting; and the curved stomach has no blind appendage. All these fish have the teeth feebly developed, the eye large, and the bones thin; while they are remarkable for their uniformly black coloration. The whole of them are deep-sea fishes, with an apparently almost cosmopolitan distribution, some of them having been taken at a depth of over two thousand fathoms. Whereas the body of the typical genus is covered with thin cycloid scales, in another type the place of these is taken by fine granules.

Southern Salmon

By this name may be designated two genera of fresh-water fish, constituting a family which represents the salmonoids in the Southern Hemisphere; the zebra salmon (*Haplochiton zebra*) being figured as an example of the typical genus. Like the salmon and herrings, devoid of barbels, these fish agree with the former in the presence of a fatty fin, but differ in having the margin of the upper jaw formed solely by the premaxillary bones. The body may be either naked or covered with scales; the gill opening is wide; false gills are

present; and the air bladder is simple. The ovaries are in the form of plates, and, in the absence of a duct, the eggs fall into the abdominal cavity. The species of the typical genus, which, although devoid of scales, are externally very similar in appearance to trout, are confined to the lakes and rivers of Chili and the extreme south of Patagonia and the Falkland islands. In South Australia and New Zealand the family is represented by the genus *Prototroctes*, in which the body is scaled and the jaws are armed with minute teeth; the New-Zealand species being commonly known to the colonists as the grayling.

The Salmon Tribe — Family *SALMONIDÆ*

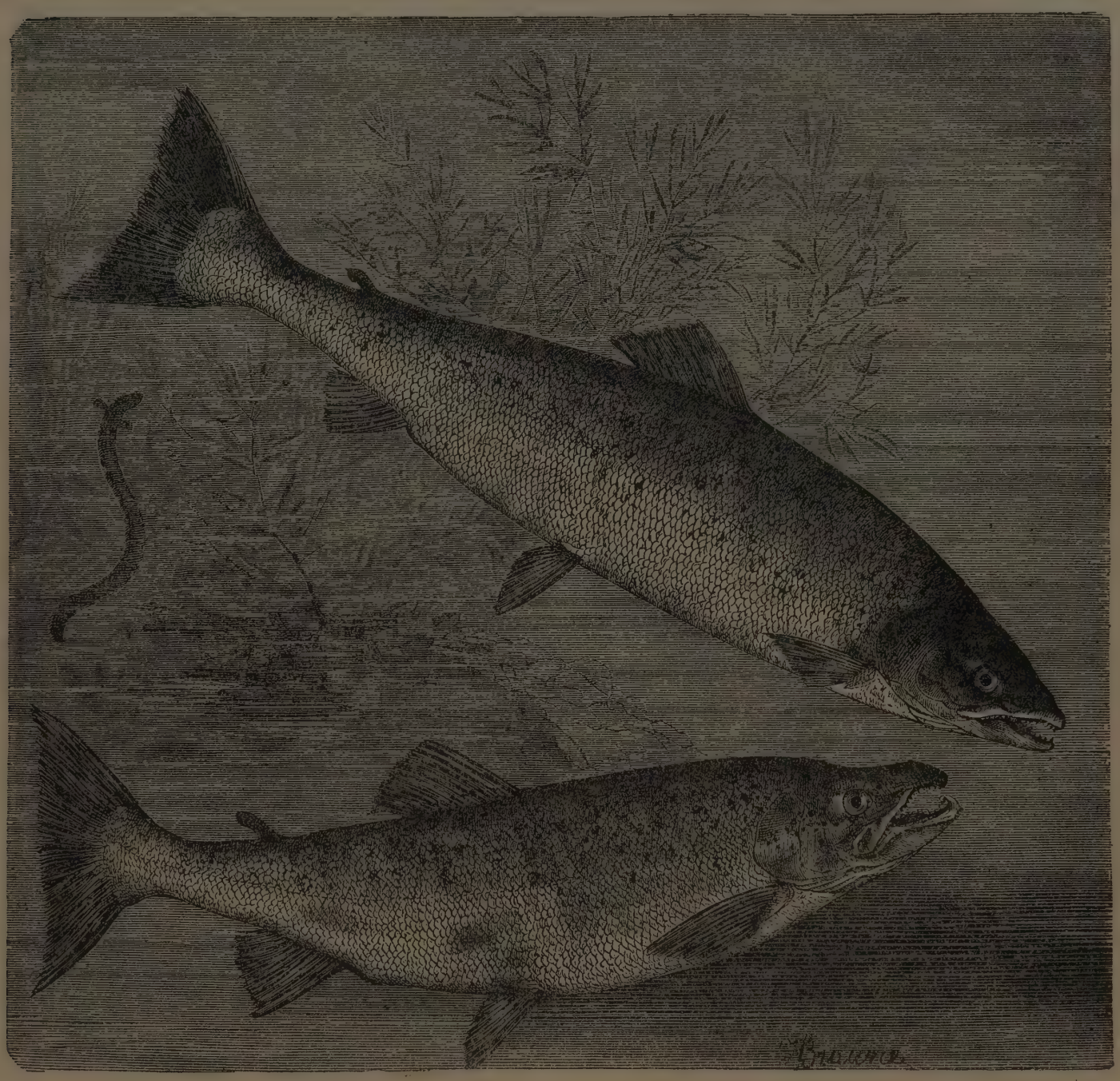
With the salmon tribe, which include the finest and "gamest" of all fresh-water fish, we come to the last group of the true bony fishes, which may be distinguished from the preceding family by the margin of the upper jaw being



ZEBRA SALMON.

formed by the premaxillæ in front and by the maxillæ at the sides. As a rule, the body is scaled, while the head is invariably naked, the under surface of the body being rounded. Inhabiting alike salt and fresh waters, those species which spend a part or the whole of their existence in rivers or lakes are in the main confined to the Temperate and Arctic zones of the Northern Hemisphere, although one outlying genus occurs in New Zealand; and whereas the majority of the marine forms are deep-sea fishes, two genera are entirely pelagic in their habits. A considerable number of the species inhabiting fresh waters descend periodically or occasionally to the sea; and in some cases it is perhaps rather difficult to say whether these fishes should be regarded as marine or fresh water. All the salmonoids are remarkable for the excellent quality of their flesh, which in many forms is of a more or less strongly-marked pinkish hue, brought about by the crustaceans on which these

carnivorous fishes so largely feed. Fossil marine salmonoids, some of which belong to existing genera, are known from the upper Cretaceous period, several of them apparently connecting the family very closely with the herrings. As mentioned before (p. 2862) the more typical members of the family have the parietal bones of the skull separated from one another by the supraoccipital, but in *Coregonus* and



SALMON AND SEA TROUT.
(One-sixth natural size.)

Thymallus they unite in front of it. There is, however, a genus (*Stenodus*) in which both conditions exist, so that there is no justification for making the union of the parietals a reason for referring *Coregonus* to a family apart. In all cases the supraoccipital extends forward to join the frontals (passing beneath the parietals in the genera where those unite), and is thus quite different from the condition obtaining in the carps and characinoids.

Typical Group

Having the dorsal nearly or quite opposite the pelvic fins, the members of the typical genus *Salmo* are characterized by the small size of the scales of the body, the strong and fully-developed teeth, and the presence of not more than fourteen rays in the anal fin, and of numerous blind appendages to the intestine. The cleft of the mouth is always deep, the maxilla extending up to or beyond the line of the eye. Conical teeth are present not only in the margins of the jaws, but likewise on the vomer and palatine bones, as well as on the tongue, although there are none on the pterygoids. The eggs are remarkable for their relatively large size; and the young, like those of most or all the other genera, are marked with dark crossbars. In the males the lower jaw is more developed than in the females, and at certain seasons may be developed into an upturned hook. The genus is confined to the colder portions of the Northern Hemisphere, its southern limits in the Old World being the rivers of the Hindu Kush and the Atlas range, and in America the rivers flowing into the head of the Gulf of California.

Few zoological subjects have given rise to a greater amount of discussion than the life history of the members of this genus, and the number of species by which it is represented. As regards the latter point, great difference of opinion still prevails among experts. Thus, for instance, Day considered that all the indigenous British salmonoids might be arranged under three specific types, namely, the salmon, the trout, and the charr; while other authorities admit an almost endless amount of species. The subject is not one which admits of discussion in this work; and we shall accordingly confine our notice to the salmon, the typical sea and river trout, and the charr. As regards the variability of these fishes we may, however, quote a passage from Dr. Günther, who writes that "these are dependent on age, sex, and sexual development, food, and the properties of the water. Some of the species interbreed, and the hybrids mix again with one of the parent species, thus producing an offspring more or less similar to the pure breed. The coloration is, first of all, subject to variation; and consequently this characteristic but rarely assists in distinguishing a species, there being not one which would show in all stages of development the same kind of coloration. The young of all the species are barred; and this is so constantly the case that it may be used as a generic, or even as a family characteristic, not being peculiar to *Salmo* alone, but also common to *Thymallus*, and probably to *Coregonus*. The number of bars is not quite constant, but the migratory trout have two (and even three) more than the river trout. In some waters river trout remain small, and frequently retain the parr marks all their lifetime; at certain seasons a new coat of scales overlays the parr marks, rendering them invisible for a time. When the salmonoids have passed this 'parr' state, the coloration becomes much more diversified. The males, especially during and immediately after the spawning time, are more intensely colored and variegated than the females; specimens which have not attained to maturity retaining a brighter silvery color, and being more similar to the female fish. Food appears to have much less influence on the coloration of the outer parts than on that of the flesh; the more variegated specimens being frequently out of condition, while well-fed individuals with pinkish flesh are of a more uniform, though bright, coloration. . . . The water has a marked influence on the colors; trout with intense ocel-

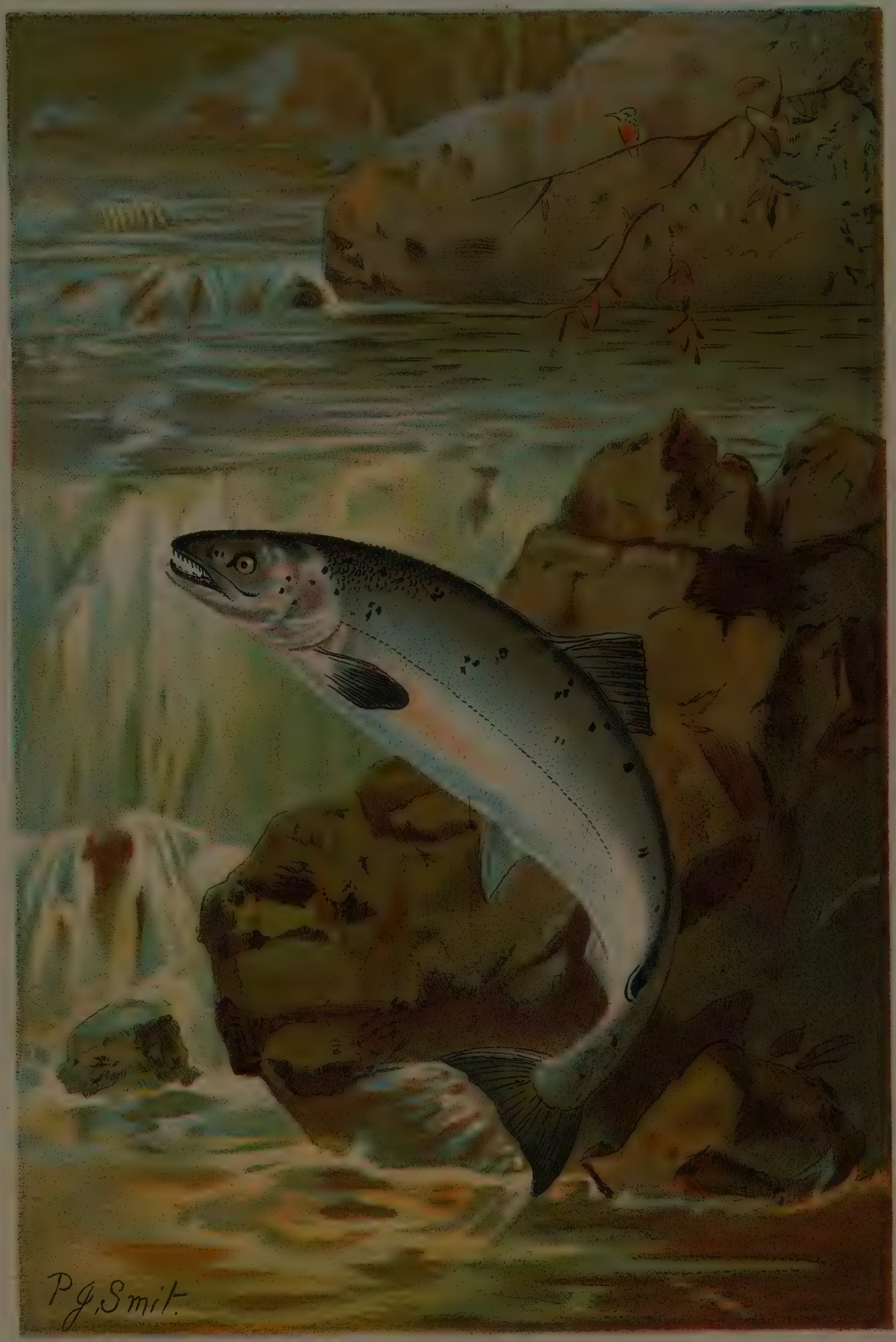
lated spots are generally found in clear rapid rivers, and in small open Alpine pools; in the large lakes with pebbly bottom the fish are bright silvery, and the ocellated spots are mixed with or replaced by X-shaped black spots; in pools or parts of lakes with muddy or peaty bottom, the trout are of a darker color generally; and when inclosed in caves or holes, they may assume an almost uniform blackish coloration." A change of color also takes place in the migratory species with the renovation of the scales, which occurs during their residence in the sea, the newly-grown portion of the silvery scales concealing the spots; and this change of coloration varies greatly according to the habitat of the individuals of some of the species. Variations of size are also common, these being for the most part dependent upon the abundance or otherwise of the food, and the extent of the area in which the fish dwell; but differences in this respect also occur among the fish hatched from the same batch of spawn, and living under the same conditions. The variations in the form and proportions of the body, and more especially in the head and jaws, according to age, sex, and season, are likewise very important, but cannot be noticed fully.

Salmon

The true salmon (*S. salar*), together with the kindred species and the trouts, belongs to a group of the genus characterized by the presence of teeth on the whole length of the vomer during at least some period of life. In the case of such a well-known fish — and also one which is generally pretty easy to distinguish from its congeners — it will be unnecessary to give a description. Dr. Günther gives, however, certain characteristics by which this fish may always be identified, and among these the following may be noticed. The scales on the tail are of relatively large size, and each transverse series running from behind the fatty fin toward the lateral line contains only eleven, or occasionally twelve, whereas in the trouts there are from thirteen to fifteen. Secondly, the main part or body of the vomer carries a single series of small teeth, which, with advancing age, gradually disappear from behind forward, so that half-grown and adult individuals have but a few remaining. Having a circumpolar distribution, the salmon ranges southward in America to 41° north latitude, and in the Old World to 43°, being unknown in any of the rivers flowing into the Mediterranean. Salmon will grow to a length of between four and five feet, and commonly reach as much as forty pounds. Much heavier fish are, however, occasionally captured. Among these may be mentioned a salmon of sixty pounds from the Severn in 1889; one from the Tay of sixty-two pounds in 1891; a third of sixty-three pounds from the Esk in 1890; another of sixty-eight pounds from the Tay in 1893; and a fifth from the same river taken in 1870, which weighed a fraction under seventy pounds. There is an earlier record of a British salmon of eighty-three pounds weight, while a Russian is stated to have scaled upward of ninety-three pounds.

For the following brief sketch of the life history of the salmon, we are indebted to a paper by Mr. G. Rooper, from which the following extracts, with some verbal alterations, are taken. After mentioning the well-known periodical migration of salmon, the writer observes that the eggs are deposited by the female "some time during the winter months, in beds of gravel over which a rapid stream flows, principally in the upper reaches of the river, where the water is more

aërated and free from pollutions of any sort—since clay, earth, or any extraneous substance would choke and destroy the embryo fish. Indeed, from the time of entering the river, the object of the fish seems to be to arrive at its source. Until they have spawned they never descend, but, resting at times in favorite pools, continually struggle upward. Only the late fish spawn in the lower waters. To such as have only seen the salmon in prime condition, the appearance of the fish when on the eve of spawning would come as a surprise. The female is then dark in color, almost black, and her shape sadly altered for the worse from that which she presented when in condition. As for the male, he is about as hideous as can well be imagined, his general color being a dirty red, blotched with orange and dark spots. His jaws are elongated, and the lower one furnished with a huge beak, as thick, and nearly as long as a man's middle finger; while his teeth are sharp and numerous, and his head, from the shrinking of the shoulders, appears disproportionally large. His skin also is slimy and disagreeable to handle, and, in fact, scarcely a more repulsive creature in appearance exists. Arrived on the spawning ground the female, then called a baggit, alone proceeds to form the nest, or 'redd' as it is termed. This she effects by a sort of wriggling motion of the lower part of her body working on the loose gravel. Many authors state that this is effected by the action of the tail, but I think the convex formation of the body at that period would prevent the tail touching the gravel, unless the fish stood at an angle of 45°, in which case the stream would carry her down. The redd, a deep trench, being formed, the female proceeds, attended by the male fish—frequently by two kippers, as they are then called—to deposit her eggs. This she does, not all at once, but in small quantities at intervals, frequently returning to the redd for the purpose. The eggs are at once fecundated by the milt of the kipper; this process going on for two or three days, the fish sinking down occasionally into the pool below to rest and recover their strength. The effect of the fertilization of the ova is to add greatly to their specific gravity; the eggs sink, and are at once covered with gravel by a similar motion on the part of the baggit to that used in the formation of the redd. Here, the process being completed, the eggs remain during a period of from one hundred and twenty to one hundred and forty days, according to the temperature of the water. At the expiration of that time, the little fish come into existence, and, after a few days, wriggle out of their gravelly bed and seek refuge under an adjacent rock or stone, where they remain in safety for some twelve or fourteen days longer. The appearance of the young fish at that time gives little promise of the beautiful form to which they subsequently attain. They are indeed shapeless little monsters, more like tadpoles than fish, each furnished with a little bag of nutriment forming a portion of the abdomen. On this, for two or three weeks, they subsist, until it is absorbed, when they take the form of fishes. They are then about one inch in length, and are known as salmon fry or samlets. A portion of the eggs are washed down the stream during the process of spawning, and become the prey of trout and other fish which attend the redds for the purpose of feeding on them. In this they do no harm whatever, for these eggs, being uncovered and unfecundated, could never arrive at maturity. The kippers, when not actually engaged in the spawning



A SALMON LEAP.

process, swim rapidly about the redd, fighting fiercely with one another. The use of the beak appears then to come into operation. Many authors erroneously describe this beak either as a weapon of offense, or as a sort of pickaxe used in digging out the redd; but it seems to me that nature has provided this singular excrescence as a protection and safeguard against the savage attacks made on each other. So large is its size, and so closely does it fit into the hole or socket formed in the upper jaw, that it would appear almost impossible for the fish even to open his mouth; but he does so, to some extent at least, and with its cat-like teeth inflicts deep, and sometimes dangerous wounds on his antagonists. As to its alleged use as a digging implement, the substance of the beak is cartilaginous, not horny, and by no means hard; it would be worn down in the process of digging in ten minutes, and, moreover, the female alone prepares the redd. After leaving the stone or rock under which it has sought protection, the young fish grows very rapidly, as is natural in one destined to attain such huge dimensions as the salmon. In the course of a month or six weeks the fry have attained to the length of four inches, and are then called 'parr'; when they bear conspicuously on their bodies transverse marks or bars, which are common to the young of every member of the salmon family. Unfortunately, there is another little fish, a humble relation of the lordly salmon, also barred, very similar in appearance, which too is called a parr, and the identity in name and similarity in appearance has occasioned great confusion and controversy, especially as they are inhabitants of the same waters, and affect to some extent each other's company. The time of their remaining in the parr stage is also a subject of dispute; and while some say two, three, or sometimes four years, my opinion is that they remain one year only. In the second April of their existence a change in the appearance of the parr occurs, which assumes the silvery scales of the adult fish, wearing his new apparel over his old barred coat. He is now called a 'smolt,' and perhaps, with a wish to exhibit himself in his new and beautiful apparel, evinces a daily increasing restlessness and desire to quit his home. With the first floods in May myriads of these lovely little fishes start on their downward journey toward the sea. It is a beautiful sight to watch their movements when descending; and for many days the river teems with them, not a square foot of water being without one when the stream is at all rapid. As fry the smolts were exposed to many dangers, but they were nothing to those which beset them as parrs on their journey toward the sea. Their enemies are legion. Trout and pike devour them; gull swoop down and swallow them wholesale. Herons, standing mid-leg deep in the water, pick them out as they pass; and even their own kindred devour them without scruple. Unluckily, too, for them, a certain number of great, hungry kelts (as the fish are called after spawning), having recovered to a great extent their condition, accompany them on their seaward journey, and prey upon their young companions as they travel; and I believe that a hungry kelt will devour upward of forty or fifty smolts in a day. Arrived at the sea, the little fish are met by a fresh array of enemies. The army of gulls is always with them, and these are reinforced by cormorants, divers, and other sea birds, besides which shoals of ravenous fish await their arrival, and assist in thinning their ranks. It is wonderful that any should escape, and, but for the extraordinary fecundity of the salmon,

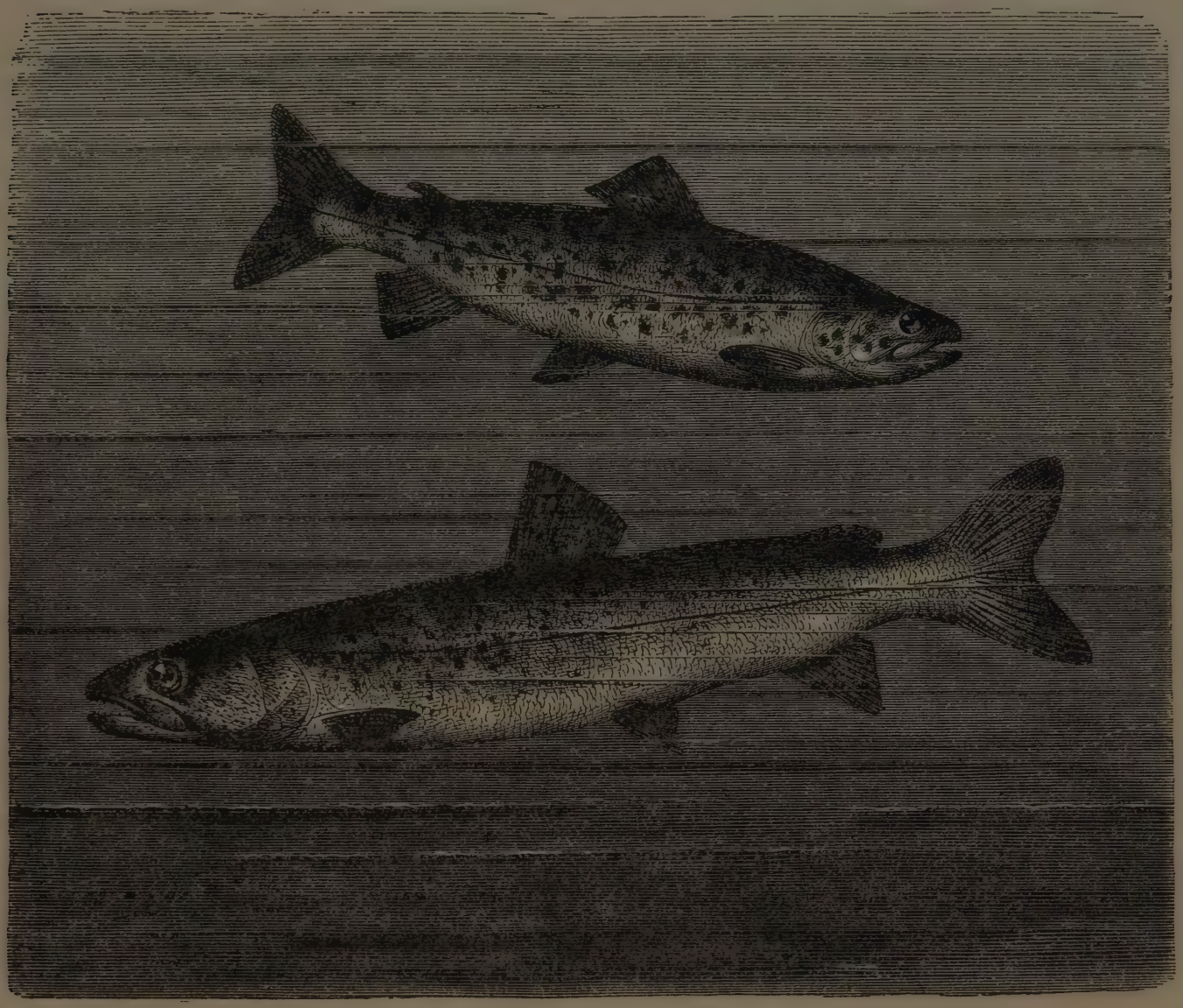
they would speedily be annihilated; but such is their prolific nature that a remnant always survives to return to the spawning beds and keep up the supply. Buckland calculated that the number of eggs laid by a salmon was about one thousand to the pound weight, a fish of fifteen pounds therefore producing fifteen thousand eggs. The food of the smolt during its sojourn in the sea is abundant, consisting chiefly of sand eels, mollusks, and marine insects. "The smolts increase accordingly very rapidly in size, and in three or four months the fish that came down five or six ounces in weight returns to the river from whence it came, a grilse of from four to six pounds; the grilse being the fifth stage of the salmon's existence. Unless accidentally prevented the grilse always returns to the river from whence it came, and after spending the autumn and winter at home, and providing for the continuance of the family by spawning, as already described, returns as a kelt to the sea in the following year, reappearing the next as a salmon of at least ten or twelve pounds weight. It should be added, that, after spawning, the fish speedily recover their color, and to a great extent their condition; the baggit at once losing her dark complexion, and the kipper discarding his hideous livery, his great beak being rapidly absorbed, his sides becoming silvery, and his back assuming a dark bluish tinge."

With reference to the statement in this account that salmon always return to the river of their birth, it may be observed that although this is generally the case, the circumstance that salmon occasionally make their appearance at the mouth of the Thames and other rivers which they have ceased to inhabit, shows that there are exceptions to the rule. The obstacles that salmon will surmount in their ascent of rivers during the return from the sea are too well known to require notice; but it is probable that the height to which they can leap has been exaggerated. The period of spawning varies with the country, taking place in the south of Sweden and North Germany at the latter part of October or early in November; while in Denmark it may be deferred till February or the beginning of March; November and December being the usual spawning months in Scotland.

Trout

In spite of their diversity of habitat, and likewise of coloration and structure, Day is of opinion that the migratory sea trout, or salmon trout (*S. trutta*), and the stationary river trout (*S. fario*), as well as the various forms from the British lakes, are nothing more than varieties of a single variable race; and it must be confessed that no one has hitherto been able to define all the nominal British species with anything like definiteness. Still, however, in the modern sense of the words there is no possibility of drawing a hard-and-fast line between a species and a variety; and the question is accordingly of no very great importance one way or another. Some of the characteristics distinguishing the salmon from the trout have been already indicated on p. 2868; and it will suffice to note very shortly some of the reasons given by Day for regarding all the British trout as referable to a single species. It is well known that sea trout — as represented not only by the typical form, but likewise by the so-called sewen (*S. cambricus*) of the Welsh rivers — are silvery in color, with black spots during their sojourn in the sea; when, however, they enter the rivers for the purpose of spawning, an orange margin appears on the upper and lower edges of the caudal, and likewise on the fatty, fin; while spots of the same color show themselves on the

body. On the other hand, the nonmigratory forms may be arranged under two types of coloration, some loch trout (which may have been originally migratory, but are now landlocked) being mainly silvery during the smolt stage, and subsequently golden and spotted; while the estuarine, lake, and river trout are all golden with purplish reflections, and more or less fully marked with black and vermilion spots. It appears, indeed, that a long residence in fresh water generally leads to the disappearance of the silvery sheen characteristic of the salmonoids while in the sea (and which is probably their primitive type of coloration), and to the promotion



MAY TROUT AND HUCHO.
(One-fifteenth natural size.)

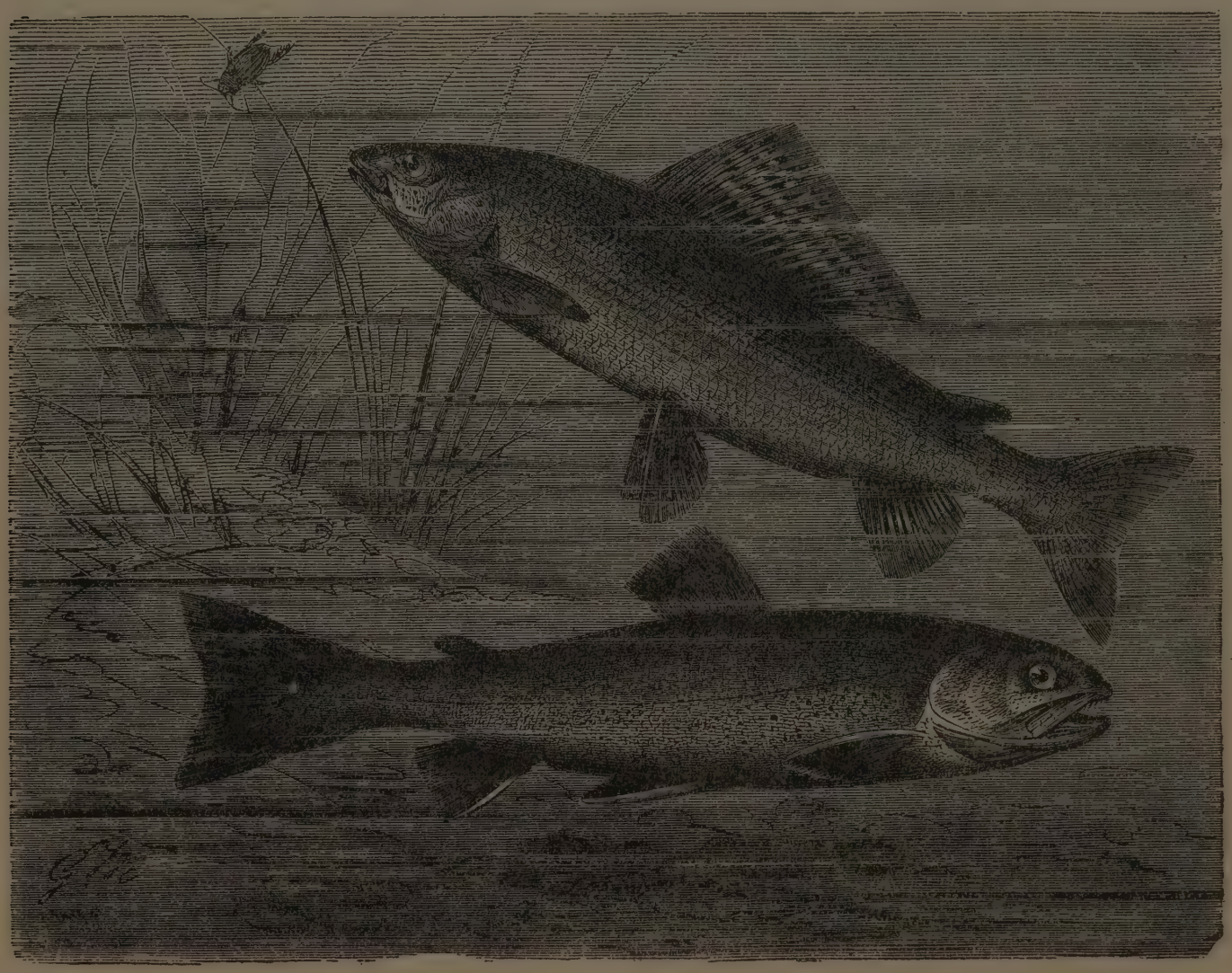
of color. As a partially transitional type between sea trout and river trout may be taken the Lochleven trout, which is somewhat silvery during the smolt stage, with the spots generally black, and no orange border to the fatty fin, but at a later stage assumes the general coloration of the river trout, although lacking the white black-based front margin to the dorsal, anal, and pelvic fins characteristic of the latter. Silvery trout do, however, occasionally occur in fresh water, where there is no possibility of their having migrated from the sea. In concluding his observations concerning the coloration of trout, Day writes that "reasons have been shown for

admitting that sea trout might breed in fresh waters without decending to the sea. That they can be traced step by step, and link by link, into the brook trout, and *vice-versâ;* that the Lochleven trout, which normally possesses a smolt or grilse stage, passes into the brook trout; and also that breeding any of these two forms together sets up no unusual phenomena." Later on, he observes that some of the chief distinctions between the sea- and fresh-water forms of trout consist in the comparatively more complete system of dentition in the fresh-water races, their generally longer head, blunter muzzle, and stronger upper jaw, irrespective of the smaller number of blind appendages to the intestine. The dentition is, however, excessively variable; and specimens with the coloration and form of the river trout taken in estuaries, or even in the sea, usually have the small number of vomerine teeth characteristic of the migratory forms; while, on the other hand, fresh-water examples with the coloration of the migratory type, may have a dentition of the nonmigratory type. "It has been asserted that brook trout invariably have a double row of teeth along the body of the vomer, and some authors have gone so far as to assert that these teeth are not deciduous. Doubtless it is not uncommon to find trout up to two pounds weight, or even more, with all the vomerine teeth thus remaining intact when a double row is present; but it is by no means rare to see only one irregularly-placed row, while in very large specimens these teeth (unless they have entirely disappeared) are always in a single row, and the vomer may be found toothless, or with only one or two teeth at the hinder edge of the head. Equally incorrect is the statement that the teeth disappear differently in different forms, for in all they first assume a single row, and then fall out, first commencing from behind. But in the rapidly growing sea trout the vomerine teeth are shed sooner than in the brook trout." The limits of our space preclude our entering further into the consideration of this interesting subject. The ordinary sea trout, which is essentially a North-European fish, much more common in Scotland than in England, and grows to a length of three feet, is depicted in the lower figure of the illustration on p. 2869; while, as an example of a spotted form, we take a variety of the Continental lake trout (*S. lacustris*), shown in the upper figure of the illustration on p. 2875. Known on the Continent as the *maiforelle* (May trout) this fish has the sides of the body marked with irregular angular or X-shaped black spots, between which are red spots, these spots becoming less numerous beneath the lateral line, while the under surface may be tinged with red. On the gill cover the spots are larger and more rounded. In the typical variety of this trout, from the Lake of Constance, the spots do not extend below the lateral line; this form being known as the *schwebforelle.* The migrations of the sea trout are very similar to those of the salmon; in Sutherland the great run of these fish to the sea taking place in June, while they reascend the rivers in autumn to spawn. Jardine writes that "in approaching the entrance of rivers, or in seeking out, as it were, some one they preferred, shoals of this fish may be seen coasting the bays and headlands, leaping and sporting in great numbers, from one to three or four pounds in weight; and in some of the smaller bays the shoals can be traced several times circling it, and apparently feeding." On the other hand, the Continental May trout spends the colder months in the deepest waters of the mountain lakes, only coming to the sur-

face in May. During the summer these trout may be seen swimming round the shoals of small fishes on which they prey until they get them well together, when they make a sudden rush among them.

Charr

Much the same difference of opinion as obtains with regard to the number of species of trout exists in the case of charr, Dr. Günther recognizing five British lacustrine species, which he regards as distinct from *S. umbla* of the Swiss lakes; while Day includes the whole of these under the latter, which is also taken to embrace the sæbling (*S. salvelinus*) of the mountain lakes of Bavaria and Austria, as well as the migratory northern charr (*S. alpinus*), ranging



GRAYLING AND CHARR.
(One-sixth natural size.)

from Lapland and Scandinavia to Iceland and the northern parts of Scotland. All charr differ from salmon and trout in having the teeth at all ages confined to the head of the vomer, instead of being distributed over its whole length; and all the forms mentioned above, which have a very uniform type of coloration, agree in having median teeth on the hyoid bone. Without committing ourselves definitely, we confess that we are inclined to agree with Day as to the specific identity of the whole of them. To illustrate the group, we have the sæbling depicted in the lower figure of the accompanying illustration. In the spawning season the upper parts of this fish are brownish green, and the sides lighter; the under surface passing

through all shades of orange to vermilion, from the throat to the pelvic fins, where the color attains its greatest intensity. The sides are ornamented with rounded spots varying from white to red in color; the dorsal fin has dark markings, and the pectoral and pelvic fins are brilliant red. This form commonly grows to a length of eight or nine inches, but the northern charr attains much larger dimensions. Day writes that "the colors of the British charr do not vary to so great an extent as in the trout, owing to their residing in deeper waters, and usually merely ascending toward the surface at night time to feed, while other changes in tint are consequent upon the breeding season. In the Lakes of Cumberland, Westmoreland, and Lancashire this fish in its ordinary state is the case charr of Pennant; when exhibiting the bright crimson belly which it assumes before spawning, it is called the red charr; when out of season, the spawn having been shed, it is distinguished by the name of the gilt charr. . . . Charr are a more delicate and apparently shorter-lived fish than trout, requiring deeper and stiller pieces of water, and a colder temperature; they have even been recorded as residing in lochs where the sun never reaches the surface of the water. They are readily destroyed by poisonous substances; while attempts to introduce them to fresh localities have not been so uniformly successful as with the trout."

The North-American charr (*S. fontinalis*), which has been successfully introduced into British waters, together with the hucho (*S. hucho*) of the Danube, differ from the foregoing in the absence of median teeth on the hyoid bone; the latter fish being shown in the lower figure of the illustration on p. 2875. The general color of the American charr is greenish,— lighter above than beneath,— beautifully shot with purple and gold, ornamented with numerous dark spots above, and fewer below the lateral line, many of which in front of the dorsal fin coalesce into streaks, and also with red spots above the aforesaid line. Most of the fins have dark markings; and in the breeding season the male assumes a black line along the under surface. These fish usually range in size from two to three pounds, although they may be larger. The hucho, on the other hand, which is readily characterized by its elongated, slender, and almost cylindrical form, attains dimensions equal to those of the salmon.

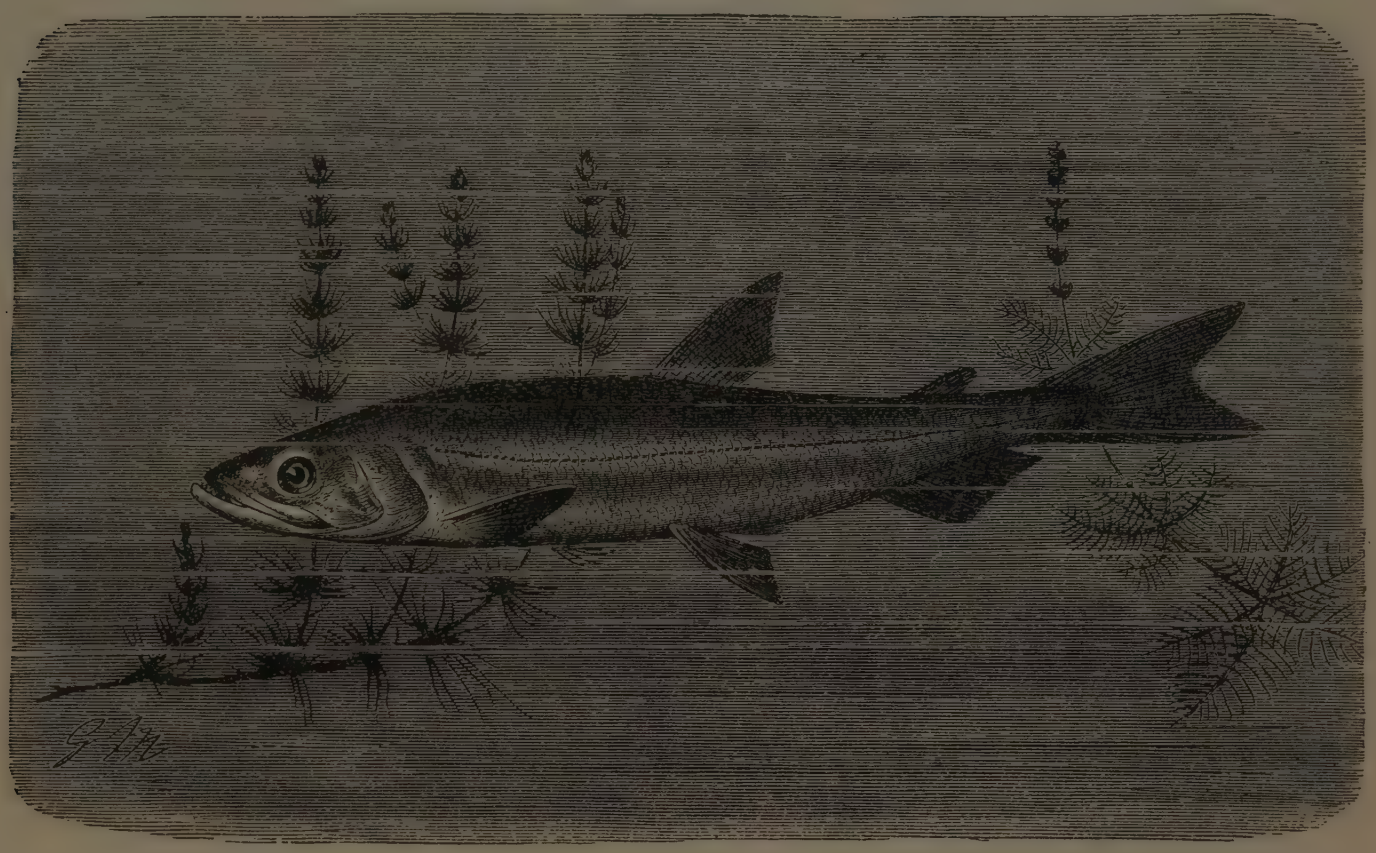
Many-Rayed Salmon

A group of migratory salmonoids (*Onchorhynchus*) inhabiting the North American and Asiatic rivers flowing into the Pacific differ from the typical genus in having more than fourteen rays in the anal fin, while their kelts are remarkable for the degree to which the jaws are hooked, and the humping of the back. An early writer in describing the hordes in which these salmon annually visit Kamchatka, states that they "come from the sea in such numbers that they stop the course of the rivers, and cause them to overflow the banks; and when the waters fall there remains a surprising quantity of dead fish upon the shore, which produces an imcomparable stink; and at this time the bears and dogs catch more fish with their paws than people do at other places with their nets." Dr. Guillemard adds that "every year the various kinds of salmon arrive at the mouths of the Kamchatkan rivers with surprising regularity. The date of the advent of these different species extends from May to mid-August; but each has its own time of arrival, which, from its constancy, appears to be more or less inde-

pendent of seasonal influences. A few fish apparently remain at or about the river mouths during the summer, and eventually return to the sea, but these are so few as to be scarcely worthy of mention. The vast majority — practically all, in fact — ascend the streams to spawn, and, having once done so, die. In the case of some species every fish appears to perish; in others, a few get back to the sea." The Oriental salmon (*O. orientalis*) of Kamchatka commonly grows to a weight of from fifty to sixty pounds; and the flesh is said to be superior in flavor to that of any other member of the family.

Smelts

The beautiful and delicately-flavored little fish known as smelts are represented by three species, one of which (*Osmerus eperlanus*) is an inhabitant of the seas and many fresh waters of Northern and Central Europe,



COMMON SMELT.
(One-half natural size.)

while the second (*O. viridescens*), which is perhaps only a variety, is confined to the opposite side of the Atlantic, and the third (*O. thaleichthys*) is found on the coasts of California. These fish form a kind of connecting link between the salmon and its allies and the under-mentioned *Coregonus*, but internally differ from both, the appendages to the intestine being short and few in number, and the eggs small, while the teeth are strongly developed. The scales are of moderate size; the cleft of the mouth is wide, with the maxillary bone extending nearly or quite to the hinder margin of the eye; the teeth of the upper jaw are much smaller than those of the lower; the vomer is armed with a transverse series of teeth, several of which are tusk-like; the palatines and pterygoids bear conical teeth; while there are also tusk-like teeth on the front of the tongue, and several longitudinal series of small ones on the hinder part of the same. In length the pectoral fins are medium.

Growing to a length of seven or eight inches in the sea, the common smelt is also found in rivers and landlocked lakes, where its size is always considerably less. The allied candlefish (*Thaleichthys*) of the Pacific coasts of North America, distinguished by its rudimental teeth, has flesh of such an oily nature that it can be burnt as a candle, although it is likewise used as food.

Coregonoids

For want of a collective English name, we must allude by a modification of their Latin title to an extensive group of mostly fresh-water salmonoids, among which the powan (*Coregonus clupeoides*), the vendace (*C. vandesius*) of Lochmaben, and the pollan (*C. pollan*) of the Irish lakes, are well-known British forms. In these fish the scales are not strikingly large; the cleft of the mouth is of moderate size, with a broad maxilla, either short or of medium length, and not extending beyond the front margin of the socket of the eye; while the teeth, if present at all, are minute and deciduous, in the adult usually remaining only on the tongue. The dorsal fin is not over long, and the caudal is deeply forked. Whereas in the small size of their eggs these fish resemble the smelts, they differ in having about one hundred and fifty blind appendages of nearly uniform length attached to the intestine. As already mentioned, these fish differ from the typical salmonoids in the relations of the bones on the top of the skull, on which account they are regarded by Professor Cope as indicating a separate family. Represented by over forty species, ranging over Northern Temperate Europe, Asia, and North America, coregonoids are for the most part entirely fresh-water fishes, although a few make periodical migrations to the sea, while the European schnæpel (*C. oxyrhynchus*) is as much a marine as a fresh-water fish. Local in their distribution in Europe, although as many as three different species may inhabit the same lake, coregonoids are extremely abundant in all the fresh waters of North America (where they are commonly known by the name of whitefish); and whereas all the British forms are small, some of the continental species may attain a length of fully two feet. The genus may be divided into groups, according to the conformation of the muzzle and jaws. Of these, the first is represented solely by the schnæpel (*C. oxyrhynchus*), which frequents the coasts and rivers of Belgium, Holland, Germany, and Sweden, and occasionally wanders into British waters. It is easily distinguished by the production of the extremity of the upper jaw into a conical fleshy snout projecting beyond the lower, while its scales are more or less nearly circular. In length, this fish grows to a foot and a half. As an example of the group in which the muzzle is obliquely truncated, with the nose projecting, we may take the marane (*C. lavaretus*), shown in the lower figure of our illustration; this fish being widely distributed in the lakes of the Continent, where its flesh is highly esteemed as food. Whereas in the Austrian lakes this fish does not exceed fourteen or fifteen inches in length, with a weight of half a pound, in Lake Constance it grows to a couple of feet in length, and from four to six pounds in weight. Living at great depths, this fish feeds on worms, insects, and water snails. While the powan belongs to another group characterized by the vertical truncation of the muzzle, the pollan and vendace are assigned to yet another division in which the lower jaw is longer than the upper, into a shallow notch of which it is fitted. As a representative of this latter group we take the pygmy marane (*C. albula*) of North-

ern Europe, shown in the upper figure of the illustration. Pollan, which grow to a length of about six inches, are largely sold in Belfast during the spawning season, at which time they come up from the deep waters of Lough Neagh to the shallows. At times they occur in enormous numbers upward of seventeen thousand having been taken on one occasion in the early part of the last century.

Grayling

The last of the salmonoids that we have space to notice are the grayling, of which the European species (*Thymallus vulgaris*) is shown in the upper figure of the illustration on p. 2877. Nearly allied to the coregonoids, the grayling are readily distinguished by the greater height and length of



PYGMY MARANE AND MARANE
(One-fifth natural size.)

the dorsal fin, which includes from thirteen to twenty-three rays. The cleft of the mouth is also smaller, and the maxilla of small size. Small teeth are present in the jawbones, as well as on the palatines and the head of the vomer, but they are wanting on the tongue. The blind appendages of the intestine are less numerous than in either the salmon or the coregonoids, and the air bladder is unusually large. The range of the genus includes a large portion of Europe, Northern Asia, and the colder regions of North America. The common species is found locally over a great part of Europe, ranging from Lapland to Venice, and from England to Russia. It is, however, unknown in Ireland, and has only been introduced of late years into Scotland; while in England it is most abundant in the rivers flowing from the lime-

stone Pennine chain in the north, and the Red Sandstone districts of the central counties, and likewise in the chalk streams of the south. In the latter area grayling occasionally run to nearly four pounds in weight, but in Northern Scandinavia they may reach one pound more. In Switzerland they are found in Lake Constance and other large pieces of water. An elegantly-shaped fish, the grayling varies considerably in color according to the season of the year, the back being generally greenish brown, passing into gray on the sides, while the under parts are silvery. The sides of the head are yellow, with black spots, which also occur on the fore part of the body; and brownish-gray longitudinal stripes run in the direction of the rows of scales. The pelvic and anal fins are violet, frequently marked with brown crossbars; the pectorals are yellow, turning to red in the breeding season; while the black-bordered dorsal and caudal are generally red, although sometimes blue; the former, and sometimes also the latter, being ornamented with longitudinal dark bands or rows of spots. A second species, with smaller scales, inhabit the mountain streams of Dalmatia, but the other two are North American.

Percopsis

A remarkable fish from the fresh waters of the United States known as *Percopsis guttata*, which has the general characteristics of a salmonoid but the mouth and scales of a perch-like type, is regarded as representing a family (*Percopsidæ*) by itself, nearly allied to the salmon tribe.

The Bony Pike and Its Kindred — Suborder Ætheospondyli

The remaining groups of the Teleostomous fishes exhibit a more or less decidedly lower type of organization than those described above; and, although the sturgeons are still well represented, these groups as a whole are evidently waning ones at the present day, having only very few living forms, whereas in past epochs some of them formed the dominant types in the fish fauna of the world. The bony pike of the fresh waters of North America constitute a family (*Lepidosteidæ*) which forms the sole existing representative of a distinct suborder. While agreeing with the preceding suborders in the divisional characteristics mentioned on p. 2702, the members of this group and the next exhibit much more marked differences from all the foregoing groups than do the latter from one another. With the exception of the extinct spear beaks, the tail is of the abbreviated heterocercal type; that is to say, that while its fin is more or less nearly symmetrical, the vertebral column, which retains its primitive tapering extremity, runs in the upper half. The scales are ganoid, and very frequently quadrangular, although they may be rounded and distinctly overlapping. In the living representatives of both suborders the air bladder is connected with the œsophagus by a duct, in the same manner as in the tube-bladdered fishes; but the optic nerves simply cross one another, without any interlacing of their fibres, and there is a spiral valve to the intestine. Whereas, with the exception of one extinct group of herrings, the whole of the suborders of bony fishes hitherto noticed are unknown previous to the Cretaceous epoch, members of the two groups to be now considered were abundant in the antecedent Jurassic period. The group including the bony pike may be distinguished from the next by the full ossi-

fication of the internal skeleton; the scales being always of the typical quadrangular ganoid type, and the branchiostegal rays having no gular plate in advance of them.

Existing Family

As a family, the bony pike, of which the common species (*Lepidosteus osteus*) is shown in our illustration, are distinguished from all other fish by having the bodies of the vertebræ convex in front and concave behind, instead of having both surfaces cupped. The fins are furnished with fulcra, the dorsal and anal consisting of soft rays only, and placed far back and near the caudal, which is of the abbreviated heterocercal type; while the trunk is much longer than the abdominal portion of the vertebral column, and the branchiostegal rays are comparatively few, and have not an enameled outer surface.



BONY PIKE.
(One-sixth natural size.)

In form the body of the bony pike is elongate and subcylindrical; the long muzzle is either spatulate or beak shaped; the cleft of the mouth wide; and both the palate and jaws are armed with bands of rasp-like teeth, and also with larger conical ones. There are four gills and three branchiostegal rays on each side; and the air bladder is cellular. Bony pike, of which there are three existing species, are now confined to North and Central America and Cuba; but they are represented in the European Eocene, and by allied extinct genera in the Eocene and Miocene strata of the United States, one of these also occurring in the French Eocene. The existing forms grow to a length of six feet, and are carnivorous, feeding upon smaller fishes. They are often known by the name of gar pike, although, as mentioned on p. 2771, that title is best restricted to a totally different group.

Spear Beaks

The extinct Jurassic spear beaks (*Aspidorhynchus*) constitute a second family (*Aspidorhynchidæ*) distinguished by the normal structure of the vertebræ, the homocercal tail, and the production of the upper jaw; the general form of the body and the arrangement of the fins being very similar to that obtaining in the bony pike.

The Bowfin and Its Allies — Suborder Protospondyli

The so-called bowfin (*Amia calva*) of the fresh waters of the United States is the sole existing representative of a second and larger subordinal group, differing from the last by the imperfect ossification of the skeleton, the notochord being either persistent throughout life, or if more or less completely replaced by vertebræ, those in front of the caudal region have their bodies composed of three distinct elements (pleurocentra and intercentrum), which remain separate and alternating even when fully developed. The lower jaw is complex, and composed of several pieces; in



THE BOWFIN.
(One-fifth natural size.)

the pectoral arch the infraclavicular plate is absent; and the pectoral fin has more than three basal elements belonging to the true internal skeleton; while the tail is always abbreviated heterocercal.

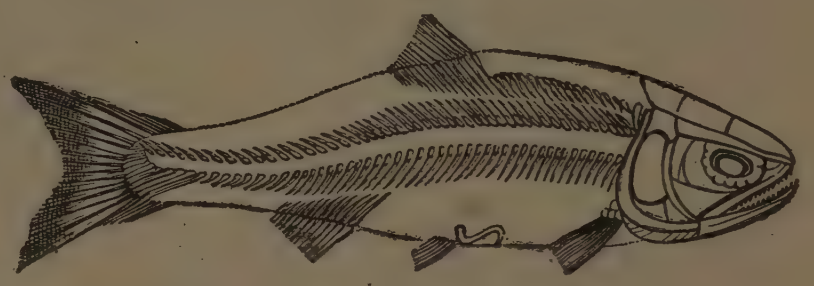
Existing Family

Together with three extinct genera, the bowfin constitutes a family (*Amiidæ*) characterized as follows: The lower jaw has its suspending arrangement directed backward, and the cleft of the mouth is wide; the degree of ossification of the vertebræ is variable, although these often form complete discs; the body is elongate or fusiform; the margins of the jaws are armed

with an outer series of large and conical teeth, internally to which are smaller ones; fulcra to the fins are either wanting or of minute size; and the dorsal fin is of variable, although usually of considerable length. Having the scales thin, somewhat rounded, and overlapping, the bowfin represents a genus in which there are no fulcra, and the long dorsal fin occupies three-fourths the length of the body, while the anal fin is short, the caudal rounded, and the throat furnished with a single gular plate, followed by a number of branchiostegal rays. The single existing species of the genus, which attains a length of two feet, is confined to the fresh waters of the United States, where it is exceedingly abundant in some of the northern lakes, but remains of extinct species have been obtained, not only from the Eocene rocks this country, but likewise from the upper Eocene and Miocene strata of Europe. Carnivorous in its diet, preying both upon other fish and also upon aquatic crustaceans and insects, the bowfin is capable of living for fully an hour out of water; and when in its native haunts, especially where the water is foul, comes frequently to the surface to breathe, rising to the surface, and taking in large mouthfuls of air without the emission of a single bubble. When near the surface, this fish often utters a bell-like note, probably due to the passage of air from the air bladder. The breeding season, during which the colors of the fish are more brilliant, lasts from May till the beginning of June. The bowfins breed among floating islands of herbage fringing the great lakes. Here they lay thousands of minute eggs on the water plants which form the base of a series of tunnels, composed partly of root fibres, and partly of a moss-like growth. Of the nest thus formed, the male fish takes entire charge till the fry are hatched; the development of the eggs being unusually rapid. The embryos, while agreeing in many respects with those of the typical ganoids, are stated to approximate in other points to those of the higher bony fishes. *Megalurus*, from the upper Jurassic, is an allied extinct genus with a short dorsal fin and fulcra; while the Jurassic *Eurycormus* and *Liodesmus* likewise belong to the same family.

Extinct Families

Among several extinct families of which the members are mostly of Jurassic age, we may notice the *Pachycormidæ* as represented typically by *Pachycormus*, in which, while the body and jaws have the same form and structure as in the bow fish, the notochord is persistent, and the ethmoid bone fused with the vomer to form a long beak; the fin rays being slender and closely set, the dorsal fin short, and fulcra absent or minute. *Eugnathus* and *Caturus* are well-known members of a third family distinguished by the vertebræ being usually represented by incomplete rings, by the large fulcra, and the short dorsal fin; the caudal fin being forked. The Pycnodonts, ranging from the Lias to the Eocene, constitute another family group, in which the body is either deeply fusiform or rhomboidal; the notochord has no ossification around it; the cleft of the mouth is narrow; the teeth are small, nodular, and

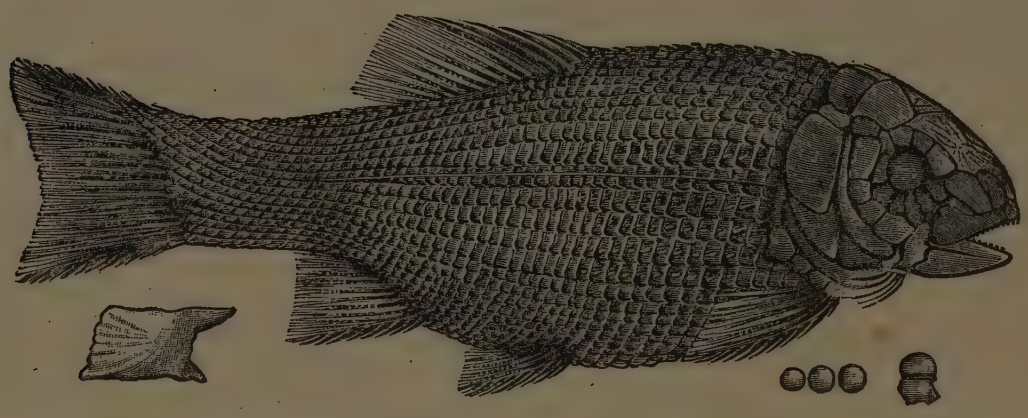


SKELETON OF AN EXTINCT AMIOID (*Caturus*).

aggregated into a pavement, without vertical successors; the gill cover is of a very simple type; branchiostegal rays and fulcra are alike absent; and the dorsal fin is elongated. The family is typically represented by the genus *Pycnodus;* but we have figured as an example of the dentition the lower jaw of the allied *Mesodon*. Yet another family (*Dapediidæ*) is represented by *Dapedius*, *Lepidotus*, and several other allied genera, in which the body is more or less deeply fusiform, the suspensory apparatus of the lower jaw either vertical or inclined forward, the cleft of the mouth narrow, the teeth cyclindrical or in the form of button-like knobs, the vertebræ not more than rings, and the dorsal fin not extending more than half the length of the body. In this family the teeth have vertical successors; and while some of the earlier genera date from the Trias, the scale tooth (*Lepidotus*), of which an example is figured in the illustration, survived till the Chalk. Some of the species of this genus attained very large



RIGHT HALF OF THE LOWER JAW OF A PYCNODONT (*Mesodon*).
(After Gaudry.)



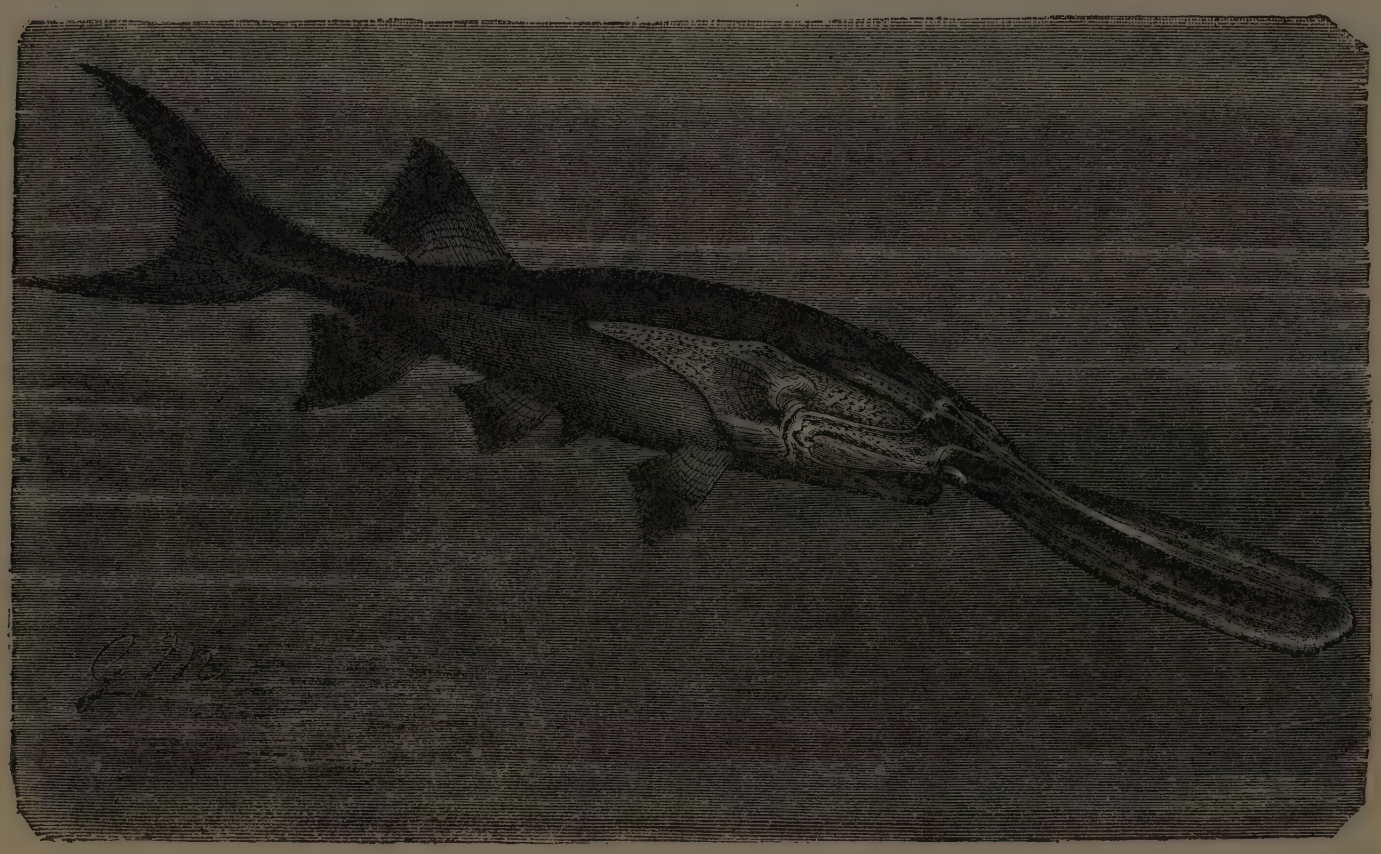
THE GIANT SCALE TOOTH WITH A DETACHED SCALE AND TEETH.
(Much reduced.)

dimensions; and their remains are beautifully preserved in the Lithographic Limestone of Bavaria. In all these the scales are of the typical quadrangular ganoid type.

The Sturgeon Tribe — Suborder Chondrostei

This important suborder brings us to the last group of the fan-finned fishes (Actinopterygii), which forms a division by itself differing in several important particulars from the one including the whole of the foregoing suborders; the more important characteristics of the first division having been given on p. 2701. Whereas in that division the number of dermal rays in the dorsal and anal fins is equal to the supporting elements in the true internal skeleton, in the present division the dermal rays are more numerous than their supports. Then, again, whereas in the

former division the pelvic fins have their superior row of supporting ossicles, or *baseosts*, rudimental or wanting, in the present group these are well developed. The living representatives of the sturgeon tribe agree with the bow fish and its allies in the want of any interlacing of the fibres of the optic nerves at their crossing, and likewise in the presence of a spiral valve to the intestine. In both the living and extinct types the tail is of either the diphycercal or heterocercal type. As a suborder, the sturgeon tribe may be characterized by the more or less completely persistent notochord, by the inferior and superior supporting ossicles (axonosts and baseosts) of the dorsal and anal fins forming a simple and regular series, and also by the presence of a pair of infraclavicular plates in the pectoral girdle. In all the known forms there is a single dorsal and anal fin, both of which

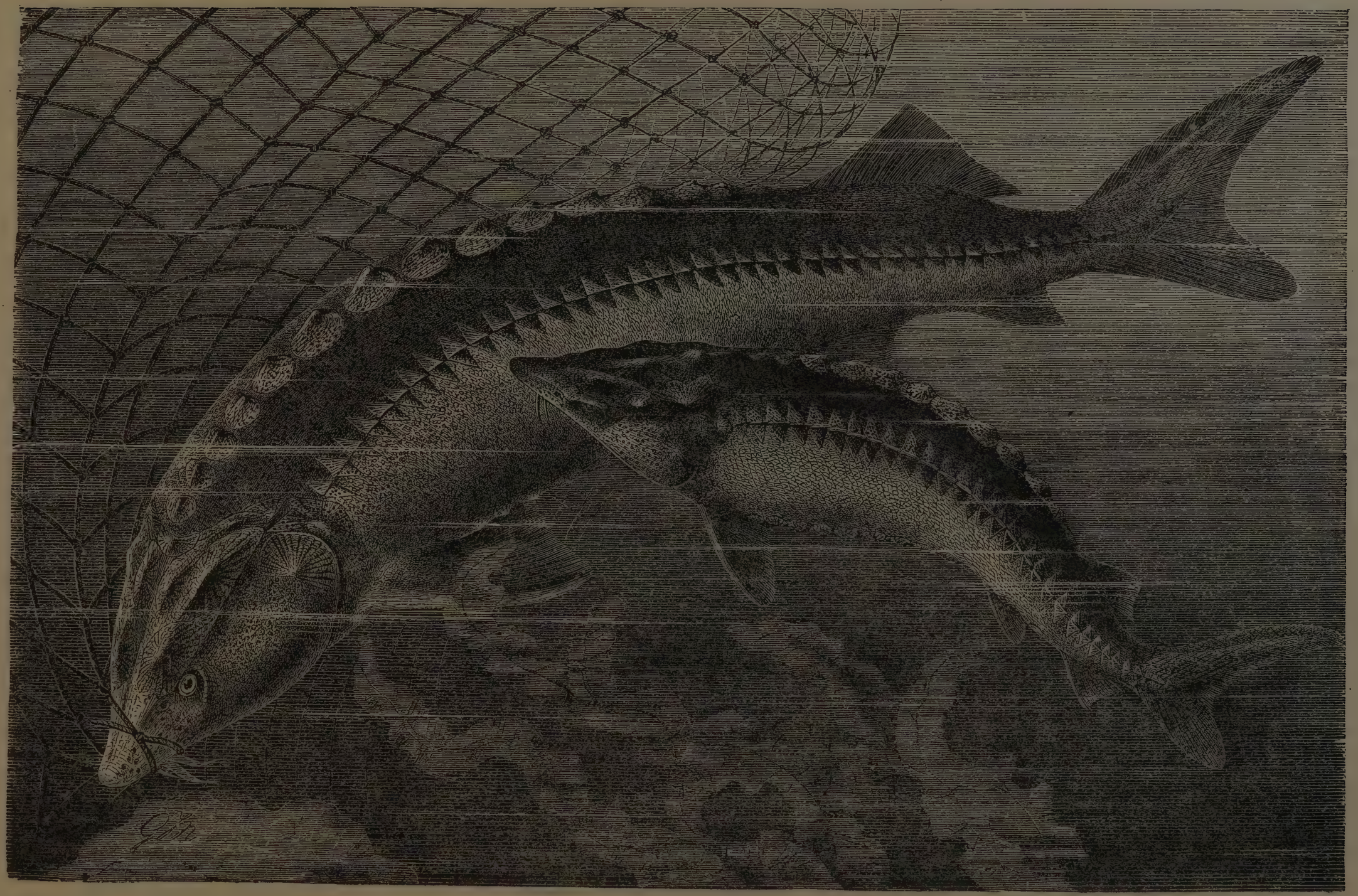


SPOON-BEAKED STURGEON.
(One-fifteenth natural size.)

are well separated from the caudal; while in the existing members the air bladder is furnished with a duct. Although represented at the present solely by the sturgeons and their allies, the group was very abundant during the Secondary epoch; and whereas the sturgeons, together with certain extinct families, form what may be termed a degenerate specialized series characterized by the absence of ganoid scales in a second and normal series the body was covered with such scales.

Toothed Sturgeons

The toothed sturgeons, of which there are two existing representatives, each forming a genus by itself, constitute the family *Polyodontidæ*. While agreeing with the other members of the series in having the cartilaginous skull invested with a series of superficial bony plates, these fishes are specially distinguished by possessing a median unpaired series of bones in this shield; by the absence of branchiostegal rays; the presence of minute teeth in the



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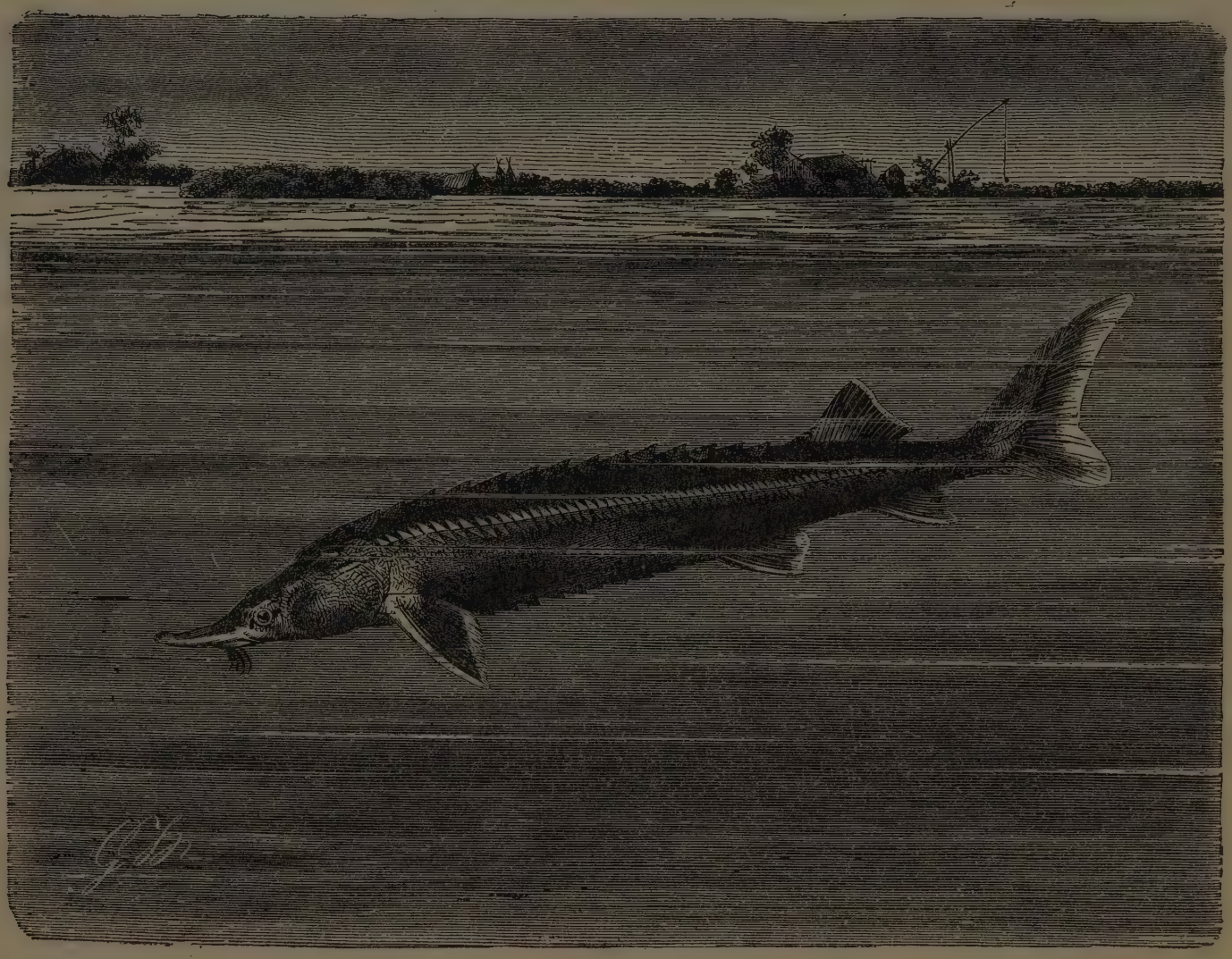
GIANT AND COMMON STURGEON.

adult; the heterocercal tail; and by the skin being either naked or with some scales on the upper lobe of the tail. The first of the two existing genera is represented by the spoon-beaked sturgeon (*Polyodon folius*) of the Mississippi, which grows to a length of six feet, and is characterized by the production of the upper jaw into a very long spoon-like beak, with thin, flexible margins, equal to one-fourth the total length in the adult, but still longer in the young. The gill cover ends in a long tapering flap; the upper lobe of the tail bears a numerous series of narrow fulcra; and the air bladder is cellular. On the other hand, the slender-beaked sturgeon (*Psephurus gladius*) from the Yang-tse-kiang and Hoangho rivers of China, differs in the more conical form of the beak, and in the large size and small number of the caudal fulcra. Growing to an enormous length — it is said as much as twenty feet — this fish agrees with the preceding in the very small size of its eyes, from which it may be inferred that both seek their prey without depending upon sight. Indeed, in the muddy waters of the rivers they inhabit, eyes can be of little use, and it has been suggested that these fish depend chiefly upon their beak, which is probably employed as an organ of touch. The flesh of both species is eaten. Among several fossil forms, we may mention the genus *Crossopholis*, of the North-American Eocene, on account of the retention of a series of oblique rows of scales on the upper lobe of the tail, as we thus have evidence of the descent of the family from fully scaled fishes.

Toothless Sturgeons

From the preceding family the typical sturgeons (*Acipenseridæ*) may be distinguished by the absence of teeth in the adult, and the presence of five longitudinal rows of bony plates on the naked body, which is elongate and subcylindrical in form, as well as by the presence of four barbels in a transverse line on the under surface of the muzzle. The muzzle is somewhat produced, and either subspatulate or conical in form, with the small, transverse mouth on its lower surface. All the vertical fins are armed with a single series of fulcra on their front edges; the dorsal and anal are situated at a moderate distance from the caudal; and the large air bladder is simple. Confined to the temperate regions of the Northern Hemisphere, sturgeons are either exclusively or partially fresh-water fish, some of them only ascending rivers for the purpose of spawning, after which they return to the sea. With the slender-beaked sturgeon, they include the largest fresh-water fishes of this region, several of the species commonly growing to ten feet, while some are much larger. The females deposit enormous numbers of extremely minute eggs, the product of a single individual having been estimated at upward of three millions during a season. This wonderful fecundity easily accounts for the enormous numbers in which sturgeon, in spite of constant persecution, still crowd the northern rivers during the spawning season. In addition to the excellence of their flesh, sturgeon are valued for their roe, from which is manufactured caviare, and for their air bladder, the inner coat of which forms the basis of isinglass. In a fossil state sturgeons are unknown before the upper part of the Eocene period. All the members of the genus are exceedingly voracious fishes, and the majority are mainly carnivorous. During the winter many or all of them crowd together, either in inlets of the sea, estuaries, or the deep pools of rivers, where they undergo a kind of hibernation; and it is stated that in

some localities they bury their noses in the mud, with their bodies and tails standing vertically upward like a series of posts. They increase very rapidly in size; and the eggs are hatched in five days. Although still abundant in the northern rivers, in those of Central Europe sturgeon have greatly decreased in numbers, and few really big fish are now taken. In the beginning of the year, when they are still torpid, sturgeon are captured by breaking the ice, and stirring up the mud at the bottom of their haunts with very long poles armed with barbed prongs. As the fish seek to escape, some are stabbed with the spears; and it is said that half a



STERLET.
(One-tenth natural size.)

score of large fish may be thus taken by a single fisherman. In summer regular fishing stations are established on the Russian rivers, where the approach of a shoal is heralded by a watchman. Upward of fifteen thousand sturgeon have been taken in a day at one of these stations; and when the fishing is suspended for a short time, a river of nearly four hundred feet in width, and five-and-twenty in depth has been known to be completely blocked by a solid mass of fish.

True Sturgeons

The common sturgeon (*Acipenser sturio*), of which a small example is shown in the illustration facing p. 2889, is the typical representative of the first genus, in which the rows of bony plates remain distinct from one another on the tail, spiracles are present on the head, the upper lobe of

the tail is completely surrounded by the fin rays, and the muzzle is either short or developed into a narrow beak of moderate length. There is some doubt as to the exact number of species of sturgeons, as these fish vary considerably according to their age, but it is probable that nearly twenty different kinds may be admitted. Among the better-known forms one of the most esteemed is the sterlet (*A. ruthvenus*), which, although rarely exceeding a yard in length, yields better-flavored flesh and finer caviare than any of the others. It is characterized by its narrow, pointed snout, and by the great number of bony plates on the sides of the body; these varying from sixty to seventy. Common in the Black Sea and Caspian, as well as in their influent rivers, the sterlet is likewise found in the Siberian rivers, while it ascends the Danube as far as Vienna. In contrast to this species may be noticed the giant sturgeon or hausen (*S. huso*), shown in our full-page illustration. Having from forty to forty-five lateral bony plates, this species may be readily distinguished by the absence of shields on the muzzle, which is rather short and pointed. It is found in the Black Sea, Caspian, Sea of Azov, and their tributaries, and occasionally enters the Mediterranean. At one time this sturgeon was to be met with in the Danube by thousands, among which specimens of upward of twenty-four feet in length were by no means uncommon; but relentless slaughter has greatly reduced not only their numbers but likewise their size, although even now fish of from 1,200 to 1,500 pounds weight are occasionally taken. These, however, are mere pygmies to certain Russian examples, one of which is stated to have weighed 2,760 pounds, and a second 3,200 pounds. Migratory in its habits, this sturgeon crowds into the Russian rivers as the ice is breaking up, when many individuals are more or less severely injured by being jammed against the floes. It appears that only full-grown fish ascend some rivers, as no small ones are found in the Danube; but in the Volga these sturgeon are stated to remain during the winter in a semitorpid condition. Although extremely powerful, the hausen is an inactive and timid fish, fleeing even from the diminutive sterlet, and passing much of its time on the mud at the river bottom, but rising occasionally to swim near the surface. In diet it is both carnivorous and herbivorous, feeding on vegetable substances, other fish, especially various kind of carp, and even water fowl. Its isinglass is inferior to that of the common sturgeon. Rarely visiting the British coasts, where it is a "royal" fish, the latter species has only from twenty-six to thirty-one lateral plates, and from eleven to thirteen down the middle of the back; the muzzle being pointed, and about equal to one-half the length of the head. It is a widely-distributed form, frequenting the coasts of both sides of the Atlantic, but absent from the Caspian, although found in the Black Sea. In Italy it ascends the rivers from March to May; and while in that country it does not commonly exceed five or six feet in length, specimens of upward of eighteen feet are on record.

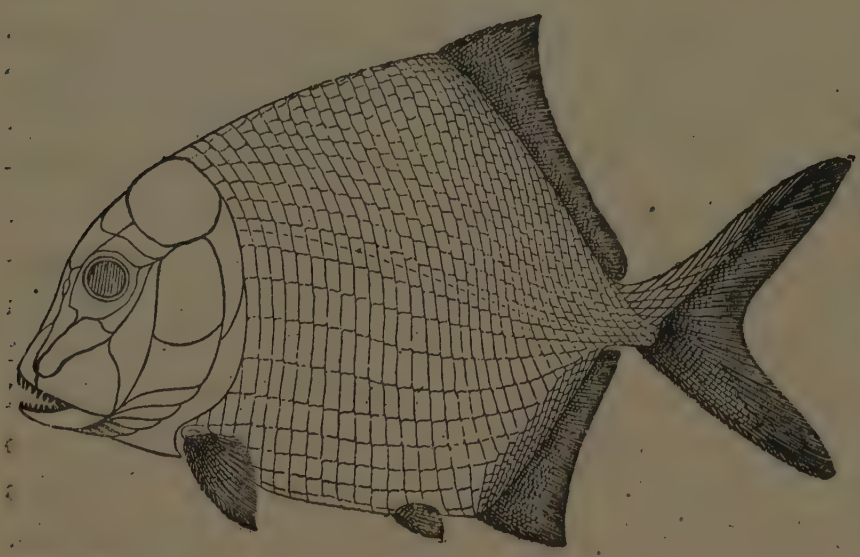
Shovel-Beaked Sturgeons

The four species of the genus *Scaphirhynchus* (which must not be confused with the toothless sturgeons) differ from the preceding genus by the production of the muzzle into a spatulate beak, by the narrow and depressed hinder portion of the tail being completely covered by the bony plates, as well as in the absence of spiracles, and by the fin rays not surrounding the extremity of the upper lobe of the tail, which terminates in a long filament.

Of the four species, one is restricted to the Mississippi river system, while the others inhabit the rivers of Central Asia; all being exclusively fluviatile in their habits.

Allied Extinct Families

The genera *Chondrosteus* and *Belonorhynchus* from the European Lias severally represent two families differing from all the modern sturgeons in the absence of a median unpaired series of bones in the head shield, and also in the possession of branchiostegal rays. In the latter family the tail is diphycercal, and there are longitudinal series of bony plates on the body; whereas in the former the tail is heterocercal, and the body is either naked or with a small series of scales on the upper lobe of the tail; both being furnished with teeth.



AN EXTINCT ACIPENSEROID FISH (*Platysomus*).

(From the Magnesian Limestone.)

Scaled Types

The scaled types of this suborder are so utterly unlike the sturgeons in external appearance that it is only by a study of their internal structure that their true affinities have been determined. They are all extinct, and mainly characteristic of the Secondary period, their remains being especially common in the British Lias. In both of the two principal families the tail is of the heterocercal type. In one family, as typified by the genus *Palæoniscus*, the body is elongated fusiform, and the teeth are slender and conical or straight. On the other hand, *Platysomus* represents a second family (*Platysomatidæ*), in which the body is rhomboidal, and the teeth — in the upper jaw mainly confined to the pterygoid bones — obtuse. In both groups the scales are of the ganoid type.

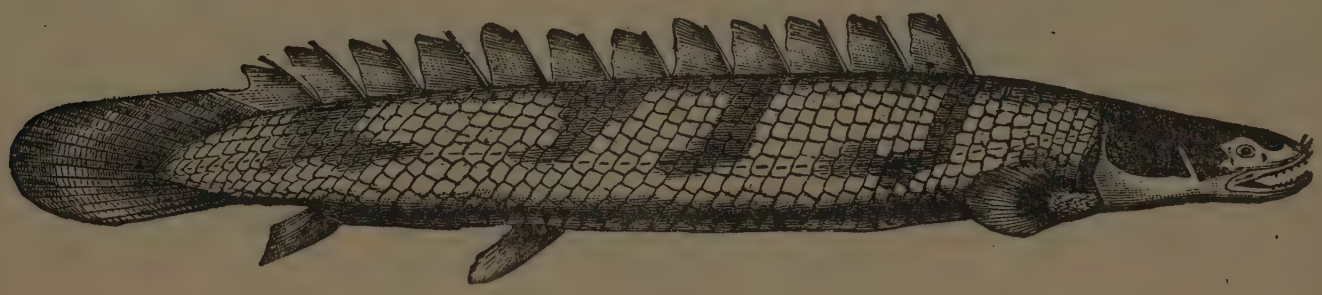
The Fringe-finned Ganoids — Order *Crossopterygii*

The whole of the members of the subclass under consideration described in the foregoing pages constitute one great order (Actinopterygii), characterized, as mentioned on p. 2702, by the fan-like structure of the paired fins, and frequently also of the caudal fin; the scales being generally of the cycloid or ctenoid type. These fishes form, indeed, the dominant group of the present day; whereas the group now to be considered is represented only by two existing species — referable to as many genera, and is mainly characteristic of the earlier epochs of the earth's history, being abundant even in the Devonian and Carboniferous epochs, since which time it has been steadily decreasing in numbers. These fringe-finned ganoids, as they may be called, have the paired fins lobate, with an internal longitudinal axis be-

longing to the true skeleton more or less fringed with dermal rays, the caudal fin being either of the diphycercal or heterocercal type. A pair of large jugular plates, bounded in some instances by a series of smaller lateral ones, and an anterior unpaired element, are developed in the branchiostegal membrane to fill up the space between the two branches of the lower jaw, and thus representing the branchiostegal rays of the first order. In all the scales are coated with ganoine, although they may be thin, overlapping, and rounded, or thick and quadrangular. The existing forms have the optic nerves simply crossing one another, a spiral valve in the intestine, and a duct to the air bladder; the presence of the latter being also shown in certain extinct types. Next to the sharks and rays, this group is one of the oldest, being well represented in the Devonian.

Existing Species

The sole existing survivors of this great group of fishes are the bichir (*Polypterus bichir*) of the Nile, and other rivers of tropical Africa, and the reed fish (*Calamoichthys calabaricus*) from Old Calabar; these constituting the family *Polypteridæ*, which has no fossil representatives, and probably forms a subordinal group by itself. In this family the notochord is more or less constricted and replaced by ossified vertebræ; the baseosts, or superior supporting elements, are rudimentary, or wanting, in the median fins; whereas the



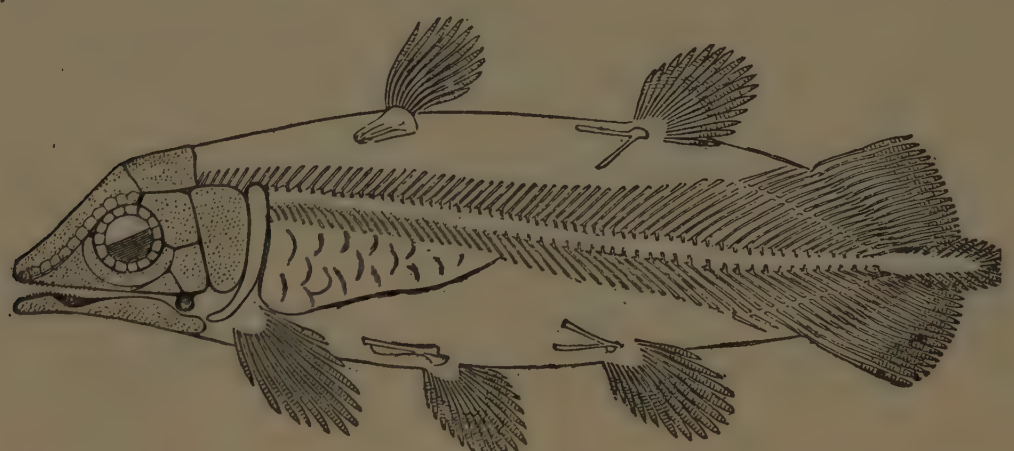
THE BICHIR.

axonosts, or inferior supports, form a regular series equal in number to the dermal fin rays with which they articulate. The scales are ganoid, and the fins without fulcra. The dorsal fin is divided into a number of finlets, each formed by a spine in front and a series of rays behind; the anal fin being situated close to the diphycercal caudal, and the vent near the end of the tail, while the whole caudal region is very short. In the bichir the body is moderately elongated; the teeth are rasp-like, and arranged in broad bands in the jaws and on the vomers and palatines, the jaws also bearing an outer series of larger pointed teeth; and the pelvic fins are well developed, but do not show the obtusely lobate structure characterizing the front pair. The large air bladder is double. The bichir is found in the Upper Nile and the rivers on the west coast of tropical Africa, examples being occasionally carried down into the Lower Nile. The number of finlets varies from eight to eighteen, and in size this fish grows to as much as four feet. Nothing is known of its habits. The reed fish is a smaller form, characterized by the great elongation of the body, and the absence of pelvic fins.

Very little can be said here as to the numerous extinct representatives of this group. One subordinal group (Actinistia) is represented by the hollow-spined ganoids (*Cœlacanthidæ*), which range from the Carboniferous to the Jurassic, and

Extinct Families

are best known by the genera *Cœlacanthus* and *Undina*. In these fishes (as shown in the accompanying figure) the notochord persists; the axonosts of the anal and two dorsal fins are fused into a single piece; in the caudal fin the dermal fin rays are each supported by a series of axonosts, equal in number to the upper and lower spines of the vertebræ; and each pelvic has a single axonost, which is not united with that of the opposite side. In these fishes the body is deeply and irregularly fusiform, with the scales overlapping, rounded, and more or less coated with ganoine. There is a gill cover and a single pair of jugular plates; the paired fins are obtusely lobate; the tail is diphycercal, frequently with a small supplemental fin at the extremity; and the air bladder is ossified. A third suborder (Rhipidistia) includes most of the other forms, especially those from the Devonian formation, and while agreeing with the preceding group in having a more or less completely persistent notochord, and the axonosts of the anal and two dorsal fins each fused into a single piece, differs in that in the caudal and other median fins the baseosts are fewer in number than in the dermal fin rays, by which they are



SKELETON OF A HOLLOW-SPINED FRINGE-FINNED GANOID (*Undina*).

(From A. S. Woodward, *Cat. Foss. Fish.*, *Brit. Mus.*)

overlapped. The suborder is represented by three well-defined families. In the first, which is typified by the genus *Holoptychius*, the lobes of the pectoral fins are long and acute, while the teeth have complex infoldings of the outer layer, somewhat after the manner of those of the primeval salamanders, and the scales are thin and cycloidal. The second family, of which *Rhizodus* is the typical genus, differs by the lobes of the pectoral fins being shorter and blunter, and also by the less complicated infoldings of the teeth. To this family belongs *Gyroptychius* from the Devonian or Old Red Sandstone of Scotland. While agreeing with the last in the obtusely lobate pectoral fins, the third family, as represented typically by *Osteolepis* of the Old Red Sandstone, is characterized by the walls of the teeth being slightly infolded only at their bases, and by the scales being of the true quadrangular ganoid type. Remains of these fishes occur in extraordinary abundance in the Old Red Sandstone of Scotland; and as this deposit is of fresh-water origin, it is evident that they were either fluviatile or lacustrine forms. The reason why these and so many other ancient creatures were enveloped in coats-of-mail has not yet been discovered.

CHAPTER IV

SHARKS AND RAYS—SUBCLASS ELASMOBRANCHII

THE last subclass of the fishes is represented by the existing sharks and rays, together with a number of more or less closely-allied extinct forms, some of the latter being the most primitive members of the order yet known. Indeed, taking these primitive types into consideration, and remembering that sharks and their allies are the oldest fishes with which we are acquainted — dating from the lower Ludlow beds of the Silurian epoch — it seems probable that the present subclass may have been the stock whence all other fishes were derived. Agreeing with the bony fishes and ganoids in having the suspending aparatus of the lower jaw movably articulated to the skull (generally with the intervention of a distinct hyomandibular element), the sharks and rays have the skeleton entirely cartilaginous throughout life; membrane bones — except in one extinct group — being entirely wanting. The gills open by separate external clefts, and have no cover. When bony elements are developed in the skin, these agree in structure with teeth, and have nothing to do with true bone. In all the living members of the subclass the optic nerves cross one another without giving off any mutually interlacing fibres, the arterial bulb of the heart is furnished with three valves, the intestine has a spiral valve, the eggs are large and detached, and an air bladder is wanting.

The whole of the existing representatives of the subclass form an ordor (Selachii) characterized by the cartilaginous internal skeleton being, as a general rule, only superficially calcified; while, except in some of the earlier extinct types, the notochord is constricted at the centre of each vertebra. The superior and inferior arches of the vertebræ are short and stout, and intercalary cartilages are very generally developed. The pectoral fin has not a segmented longitudinal central axis, its cartilaginous rays forming a fan-shaped structure radiating from an abbreviated base, into the anatomical details of which it will be unnecessary to enter here; and the axis of each pelvic fin is developed in the males into a "clasper," connected with the reproductive function. With regard to the structure of the skull, it may be mentioned that the hyomandibular usually intervenes between the palatopterygoid bar (forming the functional upper jaw, and carrying the teeth) and the cranium proper; but in the genus *Notidanus* the hyomandibular takes no share in the support of the jaws, the palatopterygoid bar articulating directly with the cranium by means of a facet behind the socket of the eye; this structure being probably the original one. We have already said that the tooth-bearing palatopterygoid bar serves the function of an upper jaw, by which name it may be conveniently referred to; and similarly the functional lower jaw is in reality the element known as Meckel's cartilage. The gills are attached to the skin by their margins, and

usually communicate with the exterior by means of five vertical slits on the sides of the neck, although occasionally the number of these clefts is increased to six or seven. Very generally the mouth is situated on the inferior aspect of the head; and the teeth carried on the functional jaws may be either sharply-pointed and separate, or blunt and articulated, so as to form a more or less pavement-like structure.



HAMMER-HEADED SHARK.
(One-tenth natural size.)

In the former case there is a continuous succession of new teeth to replace the old ones as they are worn away and shed. As a rule, the tail fin is heterocercal, with the upper lobe greatly elongated; the pelvic fins are always abdominal in position; and the dorsal fins of many extinct and a few living types bear large spines on their front edge, which, unlike those of the bony fishes, are simply imbedded in the flesh, without articulating with the internal skeleton, and are consequently immovable.

Spiracles are frequently developed on the upper surface of the head; and the intercalary cartilages already alluded to are ovoid or diamond-shaped structures occurring between the superior arches of the vertebræ. The eggs are generally invested in horny rhomboidal capsules, furnished at the four corners with long tendril-like filaments, by which they attach themselves to the stems of seaweeds and other bodies, as shown in the figure of the lesser spotted dogfish given on p. 2904. In some species, however, the eggs are hatched within the body of the female; and in all cases the embryos are furnished with external gills, which are shed before birth. All the members of the order subsist on animal substances, but whereas the typical sharks are highly predaceous creatures, seizing and devouring everything they come across, some of the largest species are armed only with small teeth, and feed on mollusks and other invertebrates. The rays, too, are largely shellfish eaters, and most of them differ from the sharks in living on or near the bottom, instead of swimming about actively at or just below the surface. All the species are typically marine, but many ascend tidal rivers, and in the Viti Levu Lake in Fiji, as well as in the Nicaragua Lake in South America, there are sharks dwelling permanently in fresh water. The species inhabiting the former lake, which is cut off from the sea by a cataract, is *Carcharias gangeticus*, common alike in the Ganges and in the Tigris, and ascending in the latter river to a distance of three hundred and fifty miles from the sea in a straight line. Then, again, a species of sawfish is found in a fresh-water lake in the Philippines. It has been commonly stated that sharks have the power of scenting their prey from a distance, since they rapidly congregate whenever animal refuse or other decomposing matter is cast overboard from a ship; but it may be suggested that such assemblages, as in the case of vultures, are rather due to one shark following the movements of another, and thus being attracted to the central point. The order was formerly divided into two subordinal groups, based upon the conformation of the body; the one group including all the sharks and dogfishes, and the other the rays and their immediate allies. It has been found, however, that although this difference in bodily form is of considerable importance in classification, yet that it does not constitute the essential line of distinction, which is based upon a difference in the internal structure of the bodies of the vertebræ. Taking this characteristic as a basis, the members of the order may be arranged in two subordinal groups; the first of which comprises the true sharks and dogfishes, while the second includes the spiny dogfishes, sawfishes, eagle rays, and rays.

The Blue Shark and Its Allies — Family *CARCHARIIDÆ*

The well-known blue shark (*Carcharias glaucus*), of which examples are depicted in our colored plate, may be taken as the typical representative of the leading family of the first suborder. Before, however, indicating the characteristics of the family, we must refer to those of the suborder, for which the name of Asterospondyli has been suggested. The essential feature of this group is to be found in the circumstance that when the bodies of the vertebræ are fully calcified, the radiating plates in the interior predominate over the circular ones, so that a

transverse section presents a star-like arrangement. All these fishes have an anal fin, and the form of the body elongated and subcylindrical, while the tail is powerful and well adapted for swimming. In no case are the pectoral fins expanded; and the spiracle is always small and may be wanting. The front teeth, and very frequently also those on the sides of the jaws, are formed on the type of a laterally compressed cone with cutting edges, at the base of which two or more smaller cones may be developed; but in one existing and many extinct genera the hinder teeth have blunt crowns adapted for crushing. The two branches of the jaws do not run parallel to each other, in consequence of which the teeth form oblique rows, whereas in the rays they are set in straight longitudinal rows. From the other sharks the members of the present family may be distinguished by the absence of spines in both the dorsal fins, of which the first is situated above the interval between the pectoral and pelvic pairs; by the presence of a nictitating membrane to the eye; and by the teeth, when fully formed, being hollow, and usually pointed. The bony elements in the skin take the form of minute granules, thus constituting the well-known "shagreen," as the dried skin is termed.

Typical Genus

In all the members of the typical genus (*Carcharias*) the muzzle is produced forward, and the inferiorly-placed mouth is crescentic and armed with large, flat, triangular, single-coned teeth, of which the upper ones differ considerably in form from those of the lower jaw. Spiracles are absent, and there is a pit at the root of the caudal fin, which has a distinct lower lobe. At the present day these sharks are represented by between thirty and forty species, of which the blue shark is one of the commonest and most widely distributed; while in a fossil state the genus is known from the Tertiary formations. The blue shark frequently attains a length of from twelve to fifteen feet, but some of the other species are stated to grow to as much as twenty-five feet. In common with the other larger members of the suborder, all these sharks are more abundant in tropical than in temperate seas; but the blue shark is by no means an uncommon visitor to British waters, more especially on the southern and western coasts of Ireland. Mr. J. T. Carrington writes that they more usually wander to the British coasts "in warm weather, especially in autumn, but they have been seen in June, and even in the month of March. They are nocturnal in their more active habits, taking rest and sleep in the daytime, often on the surface of the water, with a portion of the dorsal fin and extremity of the tail exposed above in the air. So gentle are they in their movements that, unlike many other monsters of the deep, they do not disturb the luminous creatures, which at the same time will be lighting every wavelet with their phosphorescence. Blue sharks are not very particular as to what fish they take as food, though those which are gregarious in their habits, like mackerel, pilchards, and herring, are most commonly hunted by them. It is on record that big fish, such as congers and the larger dogfish, were found in a dead specimen from Cornwall. Occasionally they become entangled in the drift nets set by the pilchard fishers, but these sharks will also take a bait. Great care is necessary in landing a hooked specimen, in case it gives a blow with its tail, which may result in serious consequences, such as broken limbs or ribs." It is a somewhat remarkable fact that in places like Aden, where sharks



BLUE SHARK.

of various kinds abound, the natives will swim and dive fearlessly in the open sea, where a European would be almost instantly devoured by these monsters. The blue shark has the whole of the upper parts slaty blue, and the under surface white.

Tope

Our next representative of the family is the small shark commonly known as the tope (*Galeus canis*), which belongs to a genus including only two species and characterized as follows: The muzzle is short and the mouth crescent shaped; very small spiracles are present; there is no pit at the root of the caudal fin, which has only a single notch; and the teeth, which are similar in the two jaws, have serrated edges, and a notch on the hinder border. The common tope, which is usually about six feet in length, although it may grow to seven feet, is a very widely-spread species, ranging over all temperate and tropical seas, and visiting the shores of such widely-separated localities as California, the British Islands, and Australia. In color it is dark gray above, and dirty white beneath. The second living species inhabits the Japanese seas; and teeth from the Tertiary formations of Europe have been referred to the genus. In habits the tope is a bottom-haunting species — especially during the winter months — and devours other fish, crustaceans, and starfishes. It is not unfrequently taken by the line, and is thus a great source of annoyance to fishermen, especially on the Norfolk coast, where considerable numbers are sometimes hooked. The young are produced alive, and it is stated that there have been instances of as many as fifty individuals in a single brood.

Hammerheads

Having teeth very similar to the true sharks, the five species known as hammerheads or hammer-headed sharks, one of which (*Sphyrna malleus*) is represented in the illustration on p. 2896, form a genus unique among fishes in the extraordinary conformation of the head. Instead of retaining the usual more or less pointed form, the front part of the head of these sharks is broad, flattened, and expanded on each side into a process, on the flat terminal surface of which is situated the eye. This, of course, is quite sufficient to distinguish the genus; but it may be added that the caudal fin has a single notch and a pit at its root, there are no spiracles, the nostrils are situated on the front edge of the head, and the mouth is crescent shaped. The teeth differ from those of the true sharks in being similar in both jaws; their margins being either smooth or serrated. Hammerheads range over all the warmer seas, the common species being sometimes taken on the British coast; and an extinct form occurs in strata of Miocene age. Growing to a length of some fourteen or fifteen feet, the common hammerhead is one of the most formidable and voracious of its tribe, and is much feared in the Indian seas.

Hounds

By this somewhat inappropriate title are designated two small British sharks, one of which (*Mustelus lævis*) is shown in the lower figure of the following illustration. Externally these sharks are not unlike the tope, but the snout is less pointed. As a genus they are characterized by the rather short muzzle; the crescent-shaped mouth; the presence of minute spiracles; the absence of a pit at the base of the caudal fin, which has scarcely any lower lobe; and the slight difference in the size of the two dorsal fins. The teeth, more-

over, are small and numerous, being either blunt or with indistinct cusps, and forming a kind of pavement-like structure; those in the upper jaw being similar to those in the lower. The smooth hound, which is the species here figured, is generally about four feet in length, although it may reach to six feet. The sides of the back are marked by a series of whitish spots, more distinct in the young than in the adult. Feeding on mollusks and crustaceans, this species (which ranges over most warm seas) produces about a dozen young at a birth, these being at-



SPINY DOGFISH AND SMOOTH HOUND.
(One-fifth natural size.)

tached by a placental structure to the walls of the uterus of the parent. Curiously enough such connection is, however, totally wanting in the young of the other British species (*M. vulgaris*). In habits the hounds are bottom-haunting species, as indeed might be inferred from the nature of their food. On the English coast

the smooth hound generally makes its appearance during the summer in pursuit of the shoals of pilchard and herring. Several other genera of this family must be passed over without notice.

The Porbeagle Group — Family *LAMNIDÆ*

Agreeing with the typical sharks in the position of the two spineless dorsal fins, the members of the present family may be distinguished by the absence of a nictitating membrane to the eye; and also by the solid structure of the fully formed teeth, which are pointed, and in most of the genera relatively large. In addition to these features, it may be noted that the gill openings are generally wide, and the spiracles either minute or wanting. This family dates from the period of the Chalk, where there occur remains of species some of which are referable to genera still existing, such as the porbeagles, while others indicate extinct generic type. The fox sharks and the gigantic *Carcharodon* are, however, unknown before the Tertiary period.

Porbeagles

The shark (*Lamna cornubica*) commonly known to the British fishermen as the porbeagle — a word supposed to be derived from its porpoise-like appearance and active predatory habits — is a type of a genus containing three existing species, and characterized by the small size of the second dorsal and anal fin, and the presence of a pit at the root of the caudal fin — of which the lower lobe is much developed — and also of a keel along the sides of the tail. The teeth are narrow and slender, with one or two pairs of small accessory cones at their bases; the edges of the main cone being smooth. The common porbeagle wanders all over the North Atlantic, and has also been taken in Japan; it does not commonly exceed ten feet in length, and its color is dull gray above and whitish beneath. Its food chiefly consists of fishes, which are apparently swallowed whole, the lancet-like teeth of this shark being apparently more adapted for seizing and holding than for tearing prey. The porbeagle is stated to be a viviparous species.

Rondeleti's Shark

The most formidable of all the existing members of the group is the gigantic Rondeleti's shark (*Carcharodon rondeletii*), distinguished from the porbeagles by the great size of the broad triangular teeth, which have strongly serrated edges, and may possess basal cusps. The existing species, which is a purely pelagic creature ranging over all the warmer seas, is known to attain a length of forty feet, one of the teeth of a specimen of thirty-six feet in length measuring two inches along the edge of the crown, and one and three-fourths inches across the base. Similar teeth are found in the Crag deposits of Suffolk, and are referred to the existing species; but from these same beds, and also from the bottom of the Pacific, between Polynesia and Australia, there are obtained other teeth of much larger dimensions, some of them measuring upward of five inches along the edge and four inches in basal depth. These teeth evidently indicate sharks beside which the existing form is a comparative dwarf; and it is not a little remarkable that the specimens dredged from the bed of the Pacific indicate that these giants must in all probability have survived to a comparatively recent

date. Observations are still required as to the mode of life and breeding habits of Rondeleti's shark. Two other species of large sharks constitute the genus *Odontaspis*. With teeth almost indistinguishable from those of the porbeagles, these species differ by the second dorsal and anal fins being nearly as large as the first dorsal, and the absence of a pit at the root of the caudal fin, and of a keel on the sides of the tail.

Fox Shark

Another species not uncommonly met with in British waters is the fox shark or thresher (*Alopecias vulpes*), the sole representative of its genus, and easily recognized by the inordinate length of the upper lobe of its tail fin, from which it derives its name. Growing to a length of fifteen feet, of which more than half is taken up by the tail, this shark has the second dorsal and anal fins very small; the caudal fin extremely elongated, and without a pit at its root; no keel on the sides of the tail; and the teeth, which are similar in both jaws, of small size, compressed and triangular, with smooth edges. Like most sharks, the thresher has a wide range, being abundant throughout the Atlantic and Mediterranean, and also found off the coasts of New Zealand and California. The comparatively small size of its teeth indicates that it is not adapted for killing large prey; and, as a matter of fact, this shark feeds chiefly upon the various species of the herring tribe and mackerel, among which it inflicts terrible destruction. It derives its name of thresher from its habit of beating the water with its long tail in order to drive the members of the shoals on which it preys into a compact mass, when they can be the more readily seized; and its voracity may be inferred from the fact that no less than nineteen mackerel and two herrings having been taken from the stomach of a single individual. It is commonly reported by sailors that threshers, in company with killers and swordfish, make attacks on whales by leaping high in the air and belaboring the unfortunate cetaceans with powerful blows of their tails as they descend; but these statements have been generally discredited by naturalists, apparently on the ground that the teeth of these sharks are not adapted for rending the flesh of large animals. It is, however, somewhat difficult on such grounds to refuse to believe the circumstantial accounts we possess, and it may be that the threshers join in the fray in order to feed on the smaller fragments left by their more powerfully armed coadjutors.

Basking Shark

The largest of the North Atlantic members of the suborder is the basking shark (*Cetorhinus maximus*), which now alone represents a genus with the second dorsal and anal fins very small, a pit at the root of the caudal fin, a keel on each side of the tail, the gill clefts very large and wide, and the teeth very small, numerous, and conical, without basal cusps, and seldom serrated at the edges. This shark, which grows to a length of over thirty feet, is regularly hunted on the west coast of Ireland for the sake of the oil from its liver, of which a single fish may yield considerably more than a ton. It derives its name from its habit of lying motionless during calm, warm weather on the surface of the water, with the tall first dorsal fin and a considerable portion of its back exposed; several individuals often consorting together. The gill arches are provided with very long rakers bearing granular tooth-like structures; and in the young the muzzle is relatively longer and more pointed than in the adult. Unless attacked,

when it can inflict blows with its tail capable of staving in the sides of a boat, this shark is perfectly harmless, its food consisting entirely of small fishes which swim in shoals, and various invertebrates. Remains of an extinct species occur in the Pliocene deposits of Belgium, while others from older Tertiary beds have been tentatively assigned to the genus.

Indo-Pacific Basking Shark—Family *RHINODONTIDÆ*

Although resembling the true basking shark in the large size of its gill clefts and the structure of its gill rakers, the gigantic species (*Rhinodon typicus*) figured in the accompanying illustration differs in having the mouth and nostrils situated near the extremity of the muzzle, as well as in the backward position of the small first



INDO-PACIFIC BASKING SHARK.
(One one-hundreth natural size.)

dorsal fin, which does not reach to the level of the highest point of the back, instead of standing immediately above it. Moreover, instead of being subcylindrical, the whole body of this shark is markedly depressed and the huge mouth forms a nearly oblong aperture, and is armed with bands of very small and numerous teeth. The sides of the tail bear a well-defined keel, and the lower lobe of the caudal fin

is well developed. In its varied coloration this fish differs markedly from the majority of sharks, being ornamented with buff spots and stripes upon a dark ground. Although probably widely distributed within the Tropics, this monster has hitherto been met with but locally. For many years the sole evidence of its existence rested upon a specimen fifteen feet long, brought ashore in Table bay in April, 1828, which fell into the hands of the late Sir Andrew Smith, who described



LESSER SPOTTED DOGFISH AND ITS EGGS
(One-fourth natural size.)

and figured it. This specimen was preserved by a French taxidermist, who sold it to the Paris Museum, where it still remains. Forty years later, in 1868, Dr. Perceval Wright, while staying at the Seychelles, met with this shark, and obtained the first authentic information about it. It does not seem to be rare in that archipelago, but is very seldom obtained on account of its large size and the difficulties attending its capture. Dr. Wright saw specimens which exceeded fifty feet in length, and one that was actually measured proved to be more than forty-five feet

long. Nothing more was heard of the species until January, 1878, in which year the capture of another specimen was reported from the Peruvian coast near Callao; finally, in the "nineties" it was discovered on the west coast of Ceylon, where two or three specimens were obtained. One of these was presented to the British Museum; and, having been mounted, is now exhibited in the Fish Gallery, where it forms one of the most striking objects, although only a young example, measuring seventeen feet from the end of the snout to the extremity of the tail. It has been stated that this fish feeds on seaweeds, but it is more probable that its food is similar to that of the basking shark.

The Dogfishes and Their Allies — Family *Scyllidæ*

Agreeing with the preceding families in the absence of spines to the dorsal fin, the dogfishes and their allies may be distinguished from the shark hitherto noticed, in which the mouth is inferior in position, by the more backward situation of the first dorsal, which is placed above or behind the line of the pelvic fins. They have no nictitating membrane to the eye; and the teeth are small, with several series generally in use at the same time. In all there are distinct spiracles.

True Dogfishes

Represented in British waters by the larger (*Scyllium canicula*), and lesser spotted dogfish (*S. catulus*), this genus is characterized by the first dorsal fin being above or behind the line of the pelvic pair; by the origin of the anal being in advance of the line of that of the second dorsal; the absence of serration of the upper edge of the caudal fin; and the small and delicate teeth, which are arranged in numerous series, and generally have a long central cusp, flanked by one or two small ones on each side. About half a score of species have been described, ranging over the coast regions of most temperate and tropical species, and all of comparatively small size; the majority having prettily spotted skins. Their food consists mainly of crustaceans and mollusks; and their flesh is eaten not unfrequently by fishermen, while in the Orkneys, where the British species are more abundant than elsewhere, it is regularly dried for winter consumption. The shagreen of their skins is also employed in wood polishing. These sharks lay eggs of the form shown in our illustration. Fossil dogfishes date from the period of the Chalk; and they are represented in the Kimeridge Clay by the extinct *Palæoscyllium*, in which the origin of the second dorsal fin is placed in advance of that of the small anal.

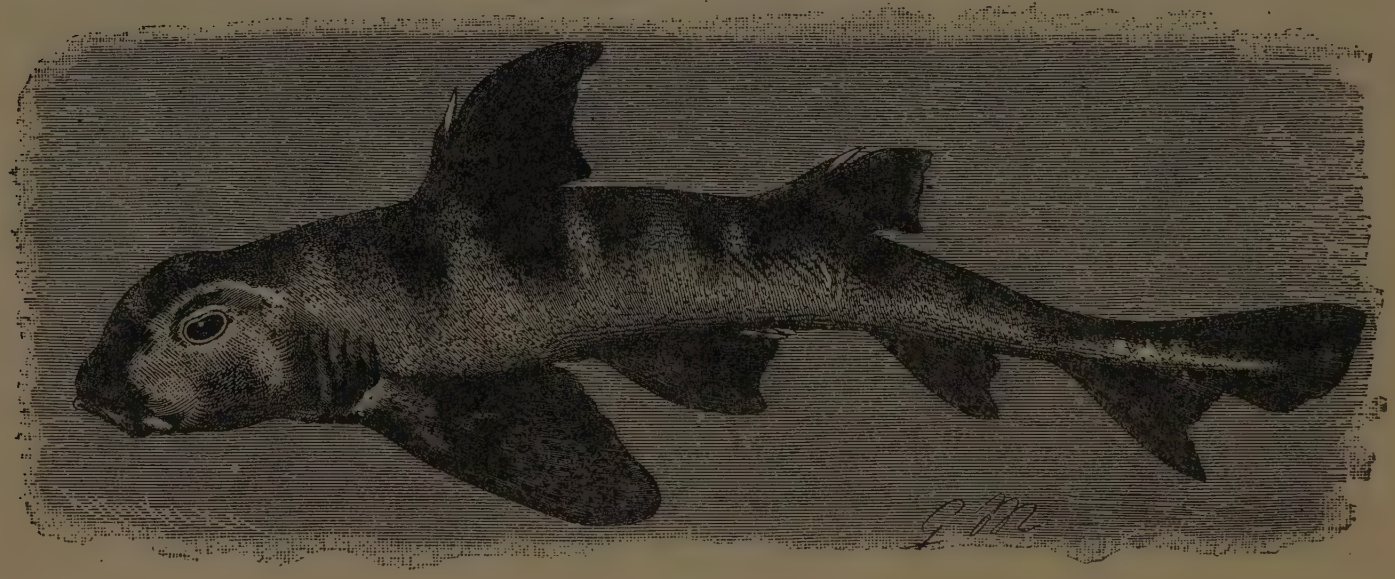
Other Genera

Among several allied genera we may especially notice the zebar shark (*Stegostoma tigrinum*) of the Indian Ocean, attaining a length of from ten to fifteen feet, and noticeable for its handsome coloration, which consists of a brownish-yellow ground color, marked with black or brown transverse bars or round spots. In this fish the first dorsal fin is above the line of the pelvic pair, while the second is in advance of the line of the anal, which is approximated to the caudal; the latter being greatly elongated, and equal to half the total length. Young specimens of this shark are generally met with near the coast, but

the adults are more or less pelagic. Dogfishes of smaller size from the Indian Ocean constitute the genus *Chiloscyllium*, in which the first dorsal fin is either above or behind the line of the pelvics; while the anal is far behind that of the second dorsal, and close to the caudal; the teeth being small and triangular, with or without lateral cusps. The existing species are very handsomely ornamented with dark bands and spots. In a fossil state the genus has been recorded from the Miocene Tertiary. Three bottom-haunting sharks from the Japanese and Australian seas have been described under the name of *Crossorhinus*, and are remarkable for the presence of leaf-like expansions of the skin on the sides of the head. As in the case of other fish similarly adorned, these structures are probably for the purpose of attracting prey; and in order that they may be well concealed, these sharks have a coloration closely assimilating to that of a rock covered with seaweed or coral-lines.

The Pavement-Toothed Sharks — Family *CESTRACIONTIDÆ*

The well-known Port Jackson shark (*Cestracion philippi*) and three allied species are the sole existing representatives of a family which was exceedingly abundant during the Secondary epoch. They differ from all the foregoing in the presence of a strong spine on the front edge of each of the two dorsal fins. The first dorsal fin is situated above the space between the pectoral and pelvic



PORT JACKSON SHARK.
(One-sixth natural size.)

pairs; and the teeth, of which several series are in use at the same time, are more or less blunt and broad, more especially in the hinder part of the jaws, although those in each oblique row are never fused together into continuous plates. In the existing genus there is no nictitating membrane to the eye; the body is moderately elongated, with the second dorsal fin in advance of the line of the anal; and the mouth is almost or quite terminal. In the dentition, the front teeth are small, numerous, and sharp, while the hinder ones are broad and flattened,

with a slight longitudinal ridge and a net-like ornamentation. The spines of the dorsal fins are smooth, covered on the sides with a thick layer of ganoine; the shagreen is fine; and the head is devoid of spines. In the existing species the egg capsules assume a remarkable screw-like form, quite unlike that of any other member of the family. The living members of the genus, none of which exceed five feet in length, have been recorded from the seas of Japan, Amboyna, Australia, the Galapagos Islands, and California; while remains of extinct forms occur in the Cretaceous and Upper Jurassic strata of Europe. Very little appears to be known as to their habits; but their food is stated to consist principally of mollusks, the hard shells of which are crushed by the pavement-like hinder teeth.



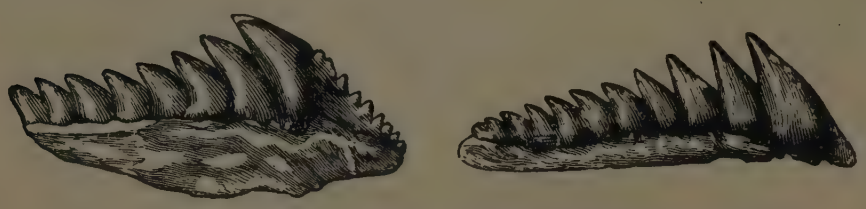
LOWER JAW OF PORT JACKSON SHARK.
(One-half natural size.)

Extinct Types Of the numerous fossil genera of the family only a very brief mention can be made. One of the earliest is the Carboniferous *Orodus*, with teeth very like those of the later *Hybodus*, ranging from the Trias to the lower Cretaceous. In the last-named genus the notochord is persistent, the bluntly conical or cusped teeth have a central and two or more lateral cusps, the fin spines are ridged, and there are two hook-like spines below each eye. *Acrodus*, with a nearly similar range, has on the other hand, blunt teeth; while the Jurassic *Asteracanthus* differs from *Hybodus* by its rhomboidal, roughened, and flattened teeth, and the star-like ornamentation of the spines of the dorsal fins. In *Synechodus* of the Chalk all the teeth are cusped; the anterior ones having a tall central cusp, flanked with from three to five small lateral pairs. An allied extinct family (*Cochliodontidæ*), confined to the Carboniferous rocks, differs by the component teeth of at least one of the oblique rows being fused into a continuous curved plate, which may be either smooth or ridged. Many of the extinct representatives of these families exceeded the Port Jackson shark in size.

The Comb-Toothed Sharks — Family *NOTIDANIDÆ*

A very remarkable family is now represented by the four species of comb-toothed sharks (*Notidanus*) and the frill-gilled shark (*Chlamydoselache anguineus*), the latter of which is shown in the illustration. Whereas in all other sharks the

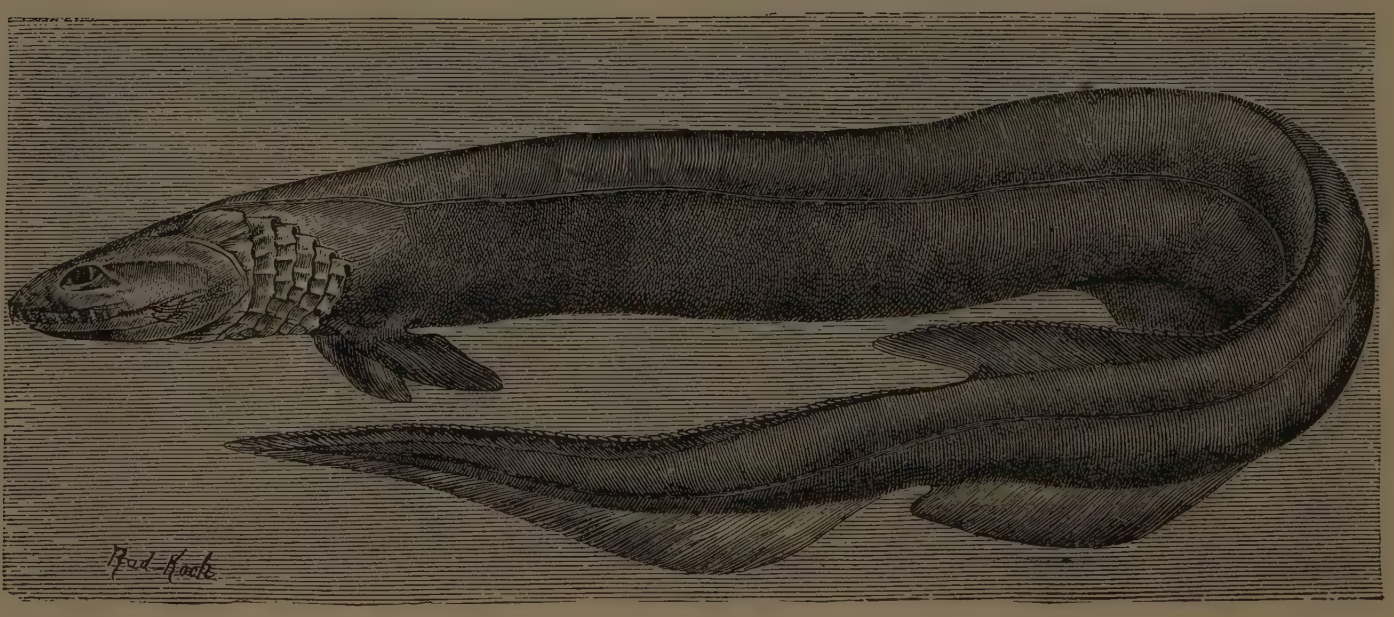
gill clefts are five in number, in the present family they are increased to six or seven; while there is a further peculiarity in regard to the structure of the skull. It has been already stated (p. 2895) that in the more typical sharks the functional lower jaw is articulated to the cranium by the intervention of the hyomandibular element; but in the Port Jackson shark this element becomes reduced in size, and the palatopterygoid bar (the functional upper jaw) has a facet by which it articulates directly with the cranium. In the present family, on the other hand, the hyomandibular takes no share in the suspension of the jaws, which are articulated to the cranium solely by means of the facet on the palatopterygoid bar; the latter joining a corresponding facet on the cranium behind the socket for the eye. In addition to their more numerous gill slits, the comb-toothed sharks are distinguished externally from all those hitherto considered by having only a single dorsal fin, which is situated far back on the body and has no spine. The eye is devoid of a nictitating membrane; the spiracles are small; and the teeth, of which several series are in use at the same time, have sharply-pointed cusps.



LOWER TEETH OF EXTINCT COMB-TOOTHED SHARKS.

Typical Genus

In the typical genus the body is moderately elongated, the mouth inferior in position, and the gill openings, which may be either six or seven in number, are devoid of flaps. The principal teeth consist of a series of cusps placed upon a long base, all inclining in one direction, and decreasing in size



FRILL-GILLED SHARK.

from the front to the back; the number of these cusps being greater in the teeth of the lower than in those of the upper jaw. With the occasional exception of some portions of the tail, the notochord persists throughout life. At the present day the range of the existing members of the genus includes most temperate and

tropical seas, some of the species reaching as much as fifteen feet in length. Whereas in the gray comb-toothed shark (*Notidanus griseus*) of the Atlantic and Mediterranean, the number of gill clefts is six, in each of the other three species it is seven. Fossil species occur from the Pliocene to the middle Jurassic; many of these, like the one of which two teeth are shown in the illustration, being of much larger dimensions than any of the existing forms. As to the habits of these sharks, there appears to be practically no information.

Frill-Gilled Shark

From the typical genus of the family the Japanese frill-gilled shark differs by the greatly elongated and slender form of the body; and by each of the six gill clefts being protected by a frill-like flap of skin. The teeth are also of a somewhat simpler structure, being similar in both jaws, and each consisting of three slender, curved, and subconical cusps, separated by a pair of rudimentary ones; while there is an unpaired median series at the extremity of the lower jaw only, instead of in both the upper and the lower. Although mainly persistent, the notochord is in part replaced by ill-developed vertebræ of the type characteristic of the suborder. Fossil teeth from the European Miocene have been assigned to this genus.

The Spiny Dogfishes and Their Allies — Family *SPINACIDÆ*

Although the members of the present family approximate in their external conformation more to the typical sharks than to the rays, yet in the structure of their vertebræ they agree with the latter. Accordingly, both the spiny dogfishes, rays, sawfishes, and their kindred are regarded as forming a suborder (Tectospondyli) distinguished from the one including the preceding families by the following characteristics: In the bodies of the vertebræ, when fully developed, the concentric calcified plates are more numerous than those radiating from the centre; and the anal fin is invariably wanting. In the more specialized forms the body is greatly depressed, and the pectoral fins attain an enormous development; while the spiracles are of large size, and always retained. The present family includes the most generalized members of the group, in which the body is cylindrical or triangular, and but very slightly depressed; the mouth being gently arched, and the muzzle blunt. The pectoral fins have no forward prolongation, and are not notched at their point of origin; and the small and lateral gill clefts may be either in the line of the pectorals, or half below. The large spiracles are placed behind the eyes; there is no nictitating membrane to the eye; and the two dorsal fins may or may not be provided with spines.

Spiny Dogfish

The common spiny, or picked, dogfish (*Acanthias vulgaris*), shown in the upper figure of the illustration on p. 2900, is the most familiar representative of a very small genus characterized by the presence of spines to the dorsal fins, and by the peculiar form of the teeth, which are similar in the two jaws, and small, triangular, and compressed, with the points much turned aside, and the cutting edge formed by the inner margin. The common species measures from three to four feet in length, and is slaty blue above, and

yellowish white beneath. It is very abundant on the British coasts, sometimes making its appearance in such incredible numbers that upward of twenty thousand were once captured in a single haul on the Cornish coast. In common with an allied species (*A. blainvillei*), this dogfish presents the peculiarity of inhabiting the two temperate zones but being unknown in the intervening tropical seas. The eggs are hatched within the body of the female, and a considerable number of young are produced at a birth. Somewhat dangerous wounds result from the spines.

Other Genera

Among other types, we may notice the genus *Centrophorus*, represented by eight European species, and a ninth from the Moluccas, all of which differ from the last by the upper teeth being erect and spear-like, with a single cusp; the dorsal spines being often very small. Apparently not exceeding five feet in length, these sharks are noteworthy on account of the depth at which they live, one of the species being caught with lines at a depth of from three to four hundred fathoms off the coast of Portugal. When hauled up, these fish are quite dead, owing to the diminished pressure. A fossil species occurs in the Chalk of Syria. In the typical genus *Spinax* the teeth in the two jaws are likewise dissimilar; but those of the lower one are broader than in the last, although with the points similarly turned aside. The genus is now represented by three small species from the Atlantic and the extremity of South America; but has been recorded from the Miocene Tertiary. The Greenland shark (*Læmargus borealis*) of the Arctic seas, which occasionally strays as far south as Britain, represents another genus characterized by the small size of all the fins and the want of spines to the dorsals, the first of which is situated considerably in advance of the pelvic pair; the skin being uniformly covered with small tubercles. In the upper jaw the teeth are small, narrow, and conical; but those of the lower jaw, which are numerous and form several series, have their points so much bent to one side that their inner margins form the cutting edge, which is not serrated. Growing to a length of fifteen feet, the Greenland shark is a determined enemy to the right whale of the same seas; and when feeding on the carcass of one of those mammals becomes so intent on its occupation as to allow itself to be harpooned without attempting to escape. Four living young are stated to be produced at a birth. Finally, we have the spiny shark (*Echinorhinus spinosus*) of the Mediterranean and Atlantic, which while agreeing with the last in the small size of the fins and the absence of spines to the dorsals, differs by the teeth being alike in both jaws, and by the presence of large rounded tubercles scattered over the skin; the body being very bulky, and the tail short. This shark lives at considerable depths, and but rarely comes to the surface.

The Extinct Petalodonts — Family *PETALODONTIDÆ*

The extinct genera *Petalodus* and *Janassa*, together with several other allied types from the Carboniferous rocks, represent a family apparently connecting the last with the more typical rays. In these fishes the body is moderately depressed,

and the pectoral fins are large and continued anteriorly toward the head. The teeth, which generally have large roots, are compressed from front to back, with the crown more or less bent backward, and either with a sharp cutting edge, or very blunt. In the mouth they were arranged in straight rows to form a pavement.

The Angel Fish — Family *Squatinidæ*

The sole existing representative of its family, the angel fish or monkfish (*Squatina vulgaris*) constitutes, so far as external form is concerned, a kind of connecting link between the sharks and the rays. Having the body as much depressed as in some of the latter, the angel fish differs in the nearly terminal position of the mouth, and also in the circumstance that while the basal portion of the pectoral fins is much produced forward, it does not extend so far as to join the head. The wide gill clefts are lateral in position, and partly covered by the base of the pectoral fins; the spiracles are wide and placed behind the eyes; and the teeth conical and pointed. Spines are wanting to the dorsal fins, which are situated on the tail; and the skin is studded with tubercles. Not unfrequently growing to a length of at least five feet, the angel fish has an almost cosmopolitan distribution, and is by no means uncommon on the British coasts, more especially in Scotland. In color it is mottled chocolate brown above, and whitish beneath, and except that it produces living young, which may number as many as twenty at a birth, its general habits are similar to those of the rays. Fossil species of angel fish range through the Tertiary and Cretaceous strata to the upper Jurassic.

The Sawfishes — Families *Pristiophoridæ* and *Pristidæ*

Unique among the whole class on account of the production of the upper jaw into a long flattened beak, furnished on either edge with a series of large, sharp, and pointed teeth, set in distinct sockets at a considerable distance from one another, the sawfishes form two well-defined families, the first of which approximates to the sharks in the position of the gill clefts, while the second agrees with the rays in the same particular. Each contains but a single existing genus, and the first is unknown previous to the present epoch.

Side-Gilled Sawfishes

The four species belonging to the first family, one of which (*Pristiophorus japonicus*) is shown in the illustration, are comparatively small fishes confined to the Japanese and Australian seas. Having the body scarcely depressed, and the pectoral fins of moderate dimensions, and not extending forward to the head, these sawfishes are distinguished by the lateral position of the gill clefts, and full development of the so-called prepalatine cartilage, and the presence of a pair of long tentacles on the lower aspect of the jaw. In habits these fishes probably resemble those of the next genus.

Distributed over all the warmer seas, the members of this genus, among which *Pristis antiquorum* of the Mediterranean and Atlantic is most commonly met with, differ from the last, not only in the inferior position of the gill clefts, but likewise

True Saw-fishes

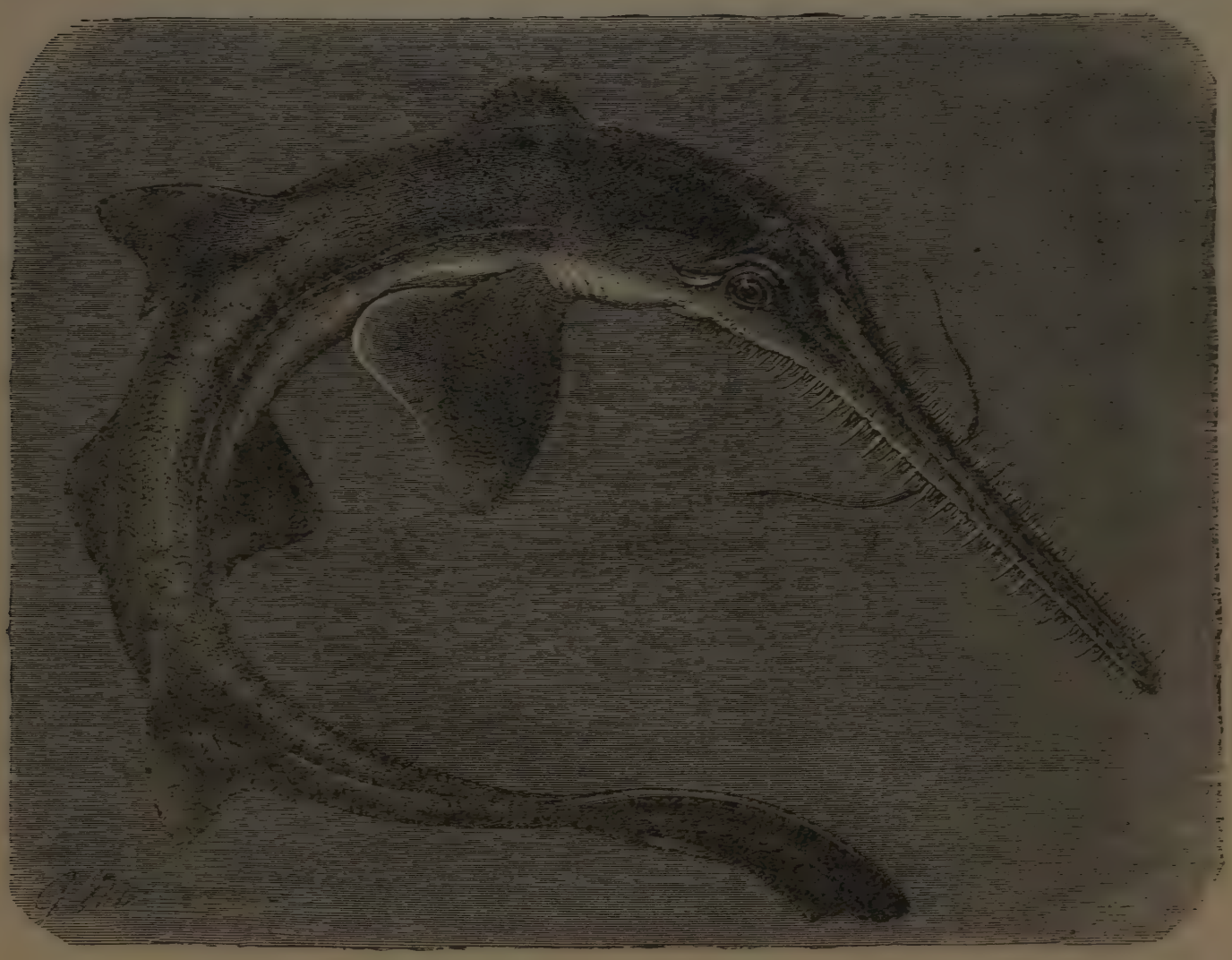
.n the small development of the prepalatine cartilages. The teeth of the saw are firmly implanted in distinct sockets of calcified cartilage, while those in the jaws are minute and blunt. The wide spiracles are situated behind the eyes; the dorsal fins are without spines, the first being placed above or near to the line of the base of the pelvic pair; and the large caudal fin may or may not have a distinct lower lobe. The saw consists internally of three, or



ANGEL FISH.
(One-twelfth natural size.)

sometimes five, hollow calcified cartilages, in the form of long tapering tubes, placed side by side, and held together by integument, which is likewise more or less hardened by the deposition of calcareous matter. Several existing species of the genus have been described, which are most abundant in the tropical seas, and some of which are distinguished by the shape of the caudal fin, and the number of pairs of teeth in the saw. These fishes not uncommonly grow to twenty feet in length, but

Day records one of twenty-four feet; in such monsters the saw may be fully six feet in length, with a basal width of one foot. Some of the Indian species ascend rivers to a considerable distance beyond the influence of the tides. Sawfishes use their weapon of offense by striking sideways through the water, and thus inflict terrific injuries, literally tearing to pieces the soft parts of such animals as they may strike; and it is stated that in the Indian estuaries large ones have been known to cut bathers completely in two. After tearing off pieces of flesh, or ripping up the body of their victim with the saw, these fishes seize and swallow the smaller fragments thus detached in their mouths. In the Malayan region the flesh of one of the species



JAPANESE SAWFISH.
(One-eighth natural size.)

is highly esteemed as food; and its fins, like those of sharks, are, after due preparation, exported to China.

Fossil remains of extinct species of the genus occur throughout a large portion of the Tertiary formations; and an allied Eocene genus, *Propristis*, differs by the circumstance that the teeth of the saw are not implanted in calcified sockets. A very remarkable type of sawfish (*Sclerorhynchus*) has left its remains in the Cretaceous rocks of Syria. Not only does this fish differ from the living forms by the distinctly depressed form of the relatively short and broad body, and the backward extension of the pectoral fins, which almost reach the pelvic pair, but the teeth,

instead of being implanted in sockets, are merely attached to the skin by an expanded and crimped base. Moreover, the central of the three rods in the interior of the saw extends to the saw's extremity, instead of stopping short; and it is not a little interesting to find that from the smaller teeth at the base of the saw a complete gradation can be traced to the tubercles dotting the skin. Assuming, as is most probably the case, that sawfishes are nothing more than highly specialized sharks, it is somewhat remarkable to find that the earliest known member of the family has a somewhat skate-like form of body, and a type of dentition which could not apparently be very readily modified into that of the existing forms.

The Beaked Rays — Family *Rhinobatidæ*

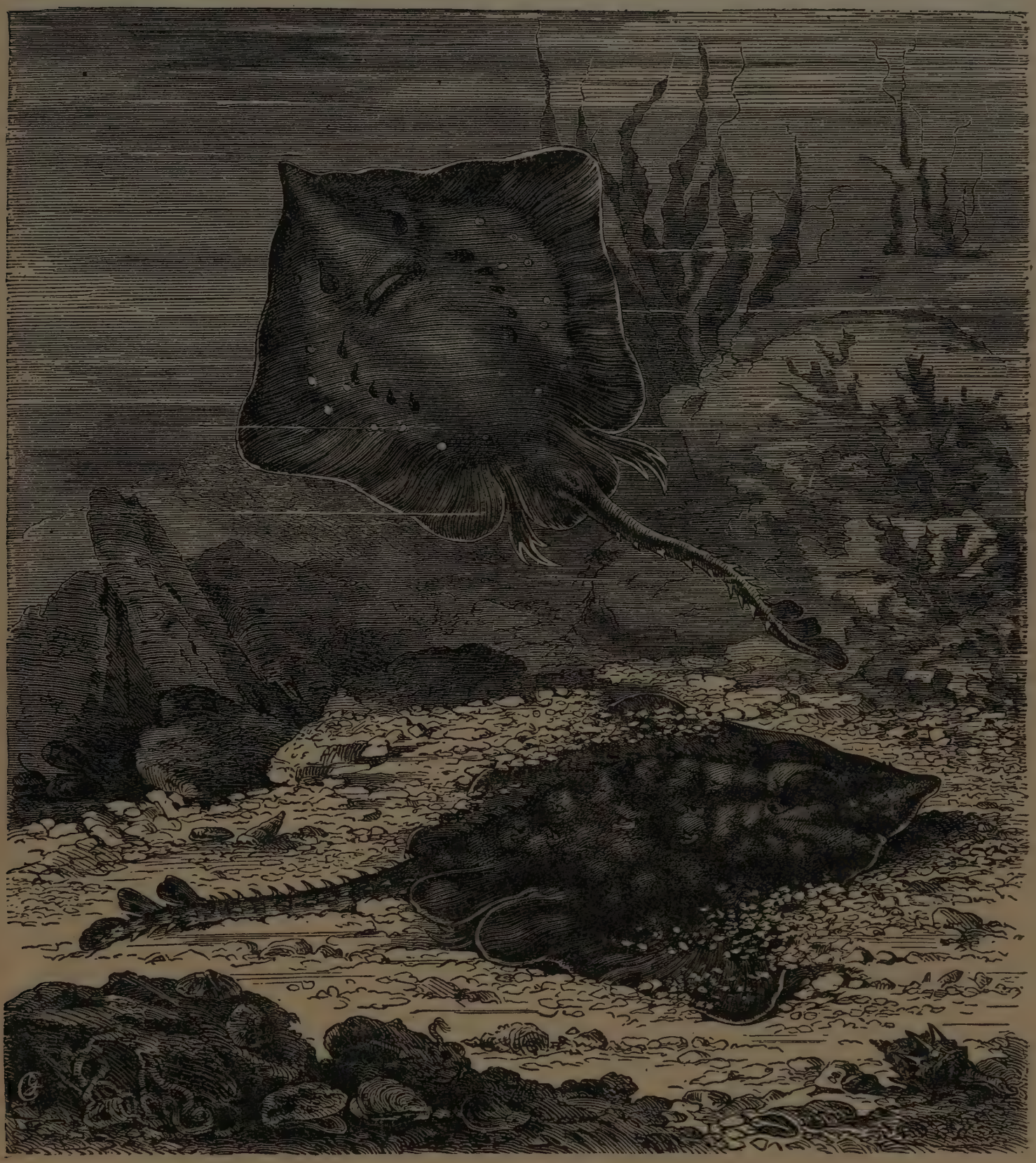
With this family we come to the first of what may properly be termed the rays and skates, in all of which the pectoral fins are so extended forward as to join the head, and thus form, with the body, the so-called "disc"; the dorsal fins being always situated on the tail, and the mouth being generally, and the gill clefts always, inferior. In the present family the tail is long and powerful, with two well-



HALAVI RAY.
(One-fifth natural size.)

developed dorsal fins, and a longitudinal fold on each side; the disc is not excessively dilated, the rayed portion of the pectoral fins stopping short of the beak; and there is no electric organ. Skates and rays in general are among the most hideous and repulsive of all fish, some of them — especially in the warmer seas — attaining enormous dimensions; while some are dangerous from the wounds inflicted by the spines

of their tails. The tooth-like tubercles on the skin frequently attain a great development, and are aggregated into prominent bosses or longitudinal ridges. Dr. Günther writes that the mode of life of these fishes is quite in accordance with the



THORNBACK SKATES.
(One-sixteenth natural size.)

form of their body, the true rays leading a sedentary life, moving slowly on the bottom of the sea, and rarely ascending to the surface. Their tail has almost entirely lost the function of an organ of locomotion, acting in some merely as a rudder.

They progress slowly by means of the pectoral fins, the broad and thin margins of which are set in an undulating motion, entirely identical with that of the dorsal and anal fins of the *Pleuronectidæ*. Like the sharks, they are exclusively carnivorous, but being unable to pursue and catch rapidly moving animals, they feed chiefly on mollusks and crustaceans. The color of their integuments assimilates, however, so closely to that of their surroundings, that other fishes approach near enough to be captured by them. The mouth of the rays being entirely on the lower surface of the head, the prey is not directly seized by the jaws; but the fish darts over its victim so as to cover and hold it down with its body, when it is conveyed by some rapid motions to the mouth. Rays do not descend to the same depth as sharks; with one exception, none are known to have been caught by a dredge working in more than one hundred fathoms. The majority are coast fishes, and have a comparatively limited geographical range, none extending from the northern into the southern temperate zone. Some of the eagle rays are, however, more or less pelagic, although when these are met with swimming in the open sea it is probable that shoal water exists at no great distance. As may be observed in many of the lochs on the west coast of Scotland, where these loathsome creatures may be seen flapping lazily alone at the bottom of the clear water, skates and rays are more or less gregarious fishes. They frequently arrive suddenly on oyster beds,— to the dismay of the owners,— where they appear to remain so long as any of the mollusks are obtainable. Writing of the species armed with caudal spines, Day observes that they "lie concealed in the sand, and are reputed to be able to suddenly encircle fish or other prey swimming above them with their long whip-like tails, and then wound them with their serrated tail spines." Many rays ascend rivers to considerable distance, and some kinds, especially in tropical America, are exclusively inhabitants of fresh waters. Nearly all lay eggs.

Typical Genus

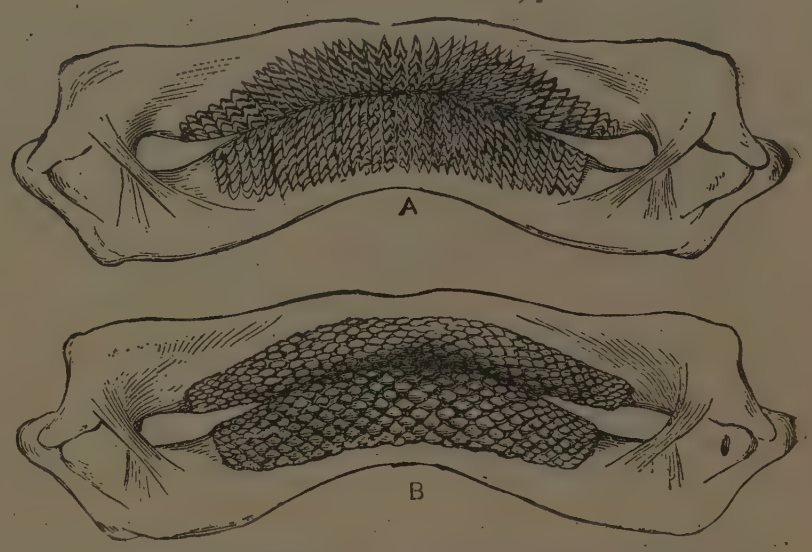
To illustrate the typical genus, which is represented by about a dozen species from the warmer seas, we take the halavi ray (*Rhinobatis halavi*), which ranges from the Mediterranean and the coasts of Western Africa to China. In these fishes the depressed body passes imperceptibly into the tail; the muzzle is produced into a long beak, the space between which and the pectoral fin is occupied by a membrane; and the wide nostrils are oblique, with their front valves separate. The blunt teeth are marked by an indistinct transverse ridge; the dorsal fins, which are situated far behind the pelvic pair, have no spines; and the caudal has no lower lobe. Fossil species are found from the Tertiary to the upper Jurassic. The allied Australian genus *Trigonorhina* differs in having the front nasal valves united, and forming a broad quadrangular flap.

Rhynchobatis

The third genus of the family, which is represented by two species from the coasts of the tropical portions of the Indian Ocean, differs in that the first dorsal fin is placed above the pelvic pair, in the presence of a lower lobe to the caudal, and also in the form of the dental plate, which is deeply undulated, so that the prominences of one jaw fit into hollows in the opposite one; the individual teeth being more or less diamond shaped. These rays do not exceed eight feet in length. Several extinct genera occur in the upper Jurassic strata of Europe.

The True Rays or Skates — Family *Raiidæ*

Represented by upward of seven British species, all of which belong to the typical genus, the true rays are characterized by the broad and rhombic form of the disc, the skin of which is generally marked with tooth-like rugosities. The tail has a longitudinal fold on each side, the degree of development of the median fins is variable, and the rayed portion of the pectoral fins extends to the muzzle. With the exception of occasional traces in the tail, electric organs are wanting. Of the typical genus we take as a well-known example the common British thornback (*Raia clavata*), of which two examples are shown in the illustration. In this genus the tail is very sharply defined from the disc, which is generally covered with rugosities; the pectoral fins stop short of the extremity of the muzzle; the pelvics are deeply notched, with a stout front cartilaginous ray; the tail carries two dorsal fins, and the caudal is rudimentary, or wanting. Most of these skates are remarkable for presenting sexual differences, which in the thornback and several other species display themselves in the dentition, the teeth of the males being sharp and pointed, while those of the opposite sex are blunt and flattened. Whereas the males of all the species are armed with patches of claw-like spines lying in grooves on the upper surface of the pectoral fins, and frequently also on the sides of the head, the females of some species have a kind of buckler of asperities on the disc, which is wanting in the other sex. In other cases the variation takes the form of a difference in color. The numerous members of this genus are in the main characteristic of the cooler seas, and while they are more abundant in the Northern than in the Southern Hemisphere, some of them approach nearer to the Arctic and Antarctic Circles than is the case with any other rays. The flesh of all of them is eatable, that of many species being commonly sold as an article of food. The common skate (*Raia batis*), which is ordinarily of from two to four feet in length, is grayish white in color, with black specks, the whole upper surface being more or less granulated. Buckland records an unusually large specimen which weighed ninety pounds. The thornback takes its name from having the whole of the upper surface studded at intervals with the above-mentioned claw-like spines; the tail being also armed with longer spines, of which a row runs along the middle of the back. The prevailing color of the upper surface is brown, with numerous lighter spots, while beneath it is pure white. Fossil skates of this genus range through the Tertiaries to the



JAWS OF MALE (A) AND FEMALE (B) THORNBACK SKATE.

upper Cretaceous. At the present day the family is represented by three genera, each with but few species, from the warmer seas; and there are likewise certain extinct generic types.

The Electric Rays — Family *Torpedinidæ*

In common with the electric eel, the members of this family are characterized by their power of communicating galvanic shocks; the organs from which this power is derived taking the form of a series of vertically-placed prisms, situated on



COMMON SKATE AND MARBLED ELECTRIC RAY.
(One-fifteenth natural size.)

each side of the front of the disc between the head and the pectoral fins. In addition to this distinctive feature, these rays are characterized by the broad and smooth disc, in which the rays of the pectoral fins do not extend in advance of the base of

the muzzle; while the median fins are well developed. The family is represented by several genera, ranging over the Mediterranean, Atlantic, and Indian Ocean, into the distinctive features of which it will be unnecessary to enter here. A well-known example of the typical genus is the marbled electric ray (*Torpedo marmorata*), represented in the lower figure of our illustration. The hexagonal prisms forming the electric organs are subdivided into a series of cells by a number of delicate transverse partitions; the cells at the two ends of the prisms being in contact with the skin, and the whole structure liberally supplied with nerves. Internally each cell is lined by a nucleated structure, within which is a mass of jelly-like substance. "The fish," writes Dr. Günther, "gives the electric shock voluntarily, when it is excited to do so in self-defense, or intends to stun or kill its prey; but to receive the shock the object must complete the galvanic circuit by communicating with the fish at two distinct points, either directly, or through the medium of some conducting body. If an insulated frog's leg touches the fish, by the end of the nerve only, no muscular contractions ensue on the discharge of the battery, but a second point of contact immediately produces them. It is said that a painful sensation may be produced by a discharge conveyed through the medium of a stream of water. The electric currents created in these fishes exercise all the other known properties of electricity; they render the needle magnetic, decompose chemical compounds, and emit the spark." Specimens measuring from two to three feet across the disc are stated to be able to disable a man by the discharge of the battery. A writer in *Land and Water*, for 1869, in reply to Buckland, observes that "I have taken two torpedos in the estuary of the Tees. You say the one you dissected had nothing in its stomach. I was curious enough to see what those I caught were living upon, so I put my knife into one, and took from him an eel two pounds in weight, and a flounder nearly one pound. The next one I opened also, and was astonished to find in him a salmon between four and five pounds weight; and what I was more astonished at was that none of the fish had a blemish of any description, showing that your idea of the fish killing his prey with his electrical force is quite correct."

The Eagle Rays — Family *Myliobatidæ*

Known also by the ill-sounding title of devilfishes, the eagle rays include the largest representatives of their tribe, and are characterized by the extreme width of the disc, owing to the great development of the pectoral fins, which are, however, interrupted at the sides of the head, to reappear as one or two small cephalic fins on the muzzle. The tail is slender and whip-like, the cleft of the mouth straight, and the teeth, when present, take the form of a solid pavement, adapted for crushing the shells of mollusks, and other hard substances. The eagle rays are inhabitants of tropical and temperate seas; and the members of some of the genera are remarkable for the development of the so-called cephalic fins into a pair of horn-like appendages, which are stated to be employed in capturing the prey and helping to convey it to the mouth. Five genera are included in the family, all the members of which appear to be viviparous.

Typical Genus The typical genus is represented by a small number of existing species, two of which are European; one of these, *Myliobatis aquila*, occasionally visiting the British coasts, where it is often termed the whip ray. In this group the head is free from the disc, and the fin on the muzzle single. The large, flat, hexagonal teeth form a tesselated pavement, highly convex in the upper, but flat in the lower, jaw; the individual teeth are arranged in seven longitudinal rows, those of the unpaired middle row being much elongated and transverse, while the others form less irregular hexagons. The whip-like tail, in addition to a dorsal fin near the root, is generally armed with a large barbed spine about the middle of its length. In the young the middle row of teeth are not larger than the lateral ones, and their relative width continues to increase throughout life. The species above named, which has an almost cosmopolitan distribution, may attain to a length of upward of fifteen feet, with a weight of about eight hundred pounds. When captured, these rays lash out with their tails, and thus inflict severe wounds with the spine. Fossil species of this genus occur through most of the Tertiary strata; and among these one from the Eocene of Egypt is remarkable for its enormous size, the teeth of the middle row being rather more than five inches in width. Although it is difficult to form an estimate of the exact size of the fish to which these teeth belonged, it is thought that the width of the disc must have been about fifteen feet.

Other Genera In the allied genus *Aëtobatis*, now represented by a single widely-spread tropical species, but common in the Tertiary formations, the muzzle carries two fins, and the dentition comprises only a single series of transversely elongated teeth, corresponding to the central row of the typical genus. In a third genus (*Rhinoptera*), of which there are seven living and several Tertiary species, the so-called fins on the muzzle are likewise double, while the tesselated teeth form five or more series. Of these the middle one is the largest, the first, or first and second, lateral series somewhat narrow, and the remainder in the form of more or less nearly regular hexagons; the dental plates of both jaws being strongly arched from back to front. The largest existing members of the family belong to the genera *Dicerobatis* and *Cephaloptera*, which are mainly confined to the tropical seas, and to which the name of devilfish might well be restricted. In the former of these the pectoral fins to not extend on to the sides of the head, which is truncated in front, and furnished with a pair of forwardly-directed appendages containing fin rays, the nostrils being widely separated. Both jaws contain numerous rows of flat or tuberculated teeth; and the whip-like tail has a single dorsal fin above and between the pelvic pair, and may be armed with a spine. In the second genus, the mouth is terminal, and teeth are present only in the lower jaw. One of the Indian representatives of the first genus is known to measure fully eighteen feet across the disc, and a weight of over one thousand two hundred pounds has been recorded. Sir W. Elliot states that the horn-like appendages "are used by the animal to draw its prey into its mouth, which opens like a huge cavern between them. The fishermen [in India] say they see these creatures swimming slowly along with their mouths open, and flapping these great sails inward, drawing in the smaller crustaceans on which they feed." The capture of such hideous monsters is a work of no little difficulty and danger, as they are quite capable of overturning a

boat; and the danger is said to be the greatest in the case of a female accompanied by its single offspring. We must not leave this family without referring to the curiously-ridged quadrangular teeth from the Chalk described under the name of *Ptychodus*, which appear to indicate an extinct type of eagle ray. In these teeth the highly-polished crown is ornamented with large transverse or radiating ridges, surrounded by a more finely-marked marginal area of variable width. They are arranged in longitudinal rows; the upper jaw having the teeth of the middle row the largest, and those of the lateral rows gradually decreasing in size; while in the lower jaw the middle teeth are rather small, and the two adjacent rows the largest.

The Sting Rays — Family *Trygonidæ*

Apparently the most specialized members of the entire group are the sting rays, in which the pectoral fins are continued uninterruptedly round the extremity of the muzzle, so that the whole of the margin of the very wide disc is formed by these fins, in the centre of which is the more elevated head and body. The long and slender tail, which is frequently armed with a serrated spine, is sharply defined from the body; and the median fins, if present at all, are either imperfectly developed, or are modified into serrated spines. The forms with armed tails, to which the name of sting ray is alone strictly applicable, inflict very severe wounds, dangerous not merely from the actual lesion, but apparently also from the presence of some poisonous substance. In the larger kinds these formidable spines may be as much as eight or nine inches in length; and, as they wear out, they are from time to time shed and replaced by new ones growing from behind. Very numerous in species, and arranged under several genera, the sting rays are most abundant in the seas of the tropics, although some range into temperate waters.

The typical genus includes some twenty-five species, one of which (*Trygon pastinaca*) ranges from the south of England westward to America and eastward to Japan. In this group the greatly elongated and tapering tail is armed with a barbed arrow-shaped spine, while the skin is either smooth or dotted over with tubercles, the nasal valves unite to form a quadrangular flap, and the teeth are flattened. Mainly characteristic of tropical latitudes, these rays are most abundant in the Indian and Atlantic Oceans, although some species are inhabitants of fresh-water lakes in Eastern tropical America. The rough ray (*Urogymnus asperrimus*) of the Red Sea and Indian Ocean, which may measure from four to five feet in length from the head to the root of the tail, is the sole representative of a second genus, characterized by the long tail being devoid of either fin or spine, although sometimes furnished with a narrow fold of skin below. The whole of the body is thickly covered with teeth-like tubercles, the teeth themselves being flattened. The third genus (*Urolophus*) — in which the tail is of medium length, furnished with a distinct terminal rayed fin, armed with a barbed spine, and sometimes with a rudimental dorsal fin, while the teeth are flattened — contains several rather small-sized species from the tropical seas, and likewise an extinct one from the Eocene rocks of Italy. A fourth genus (*Pteroplatea*), of which there are some

half-dozen representatives from temperate and tropical seas, is characterized by the great width of the disc, which is at least twice as long as wide, and also by the shortness of the thin tail, which always bears a serrated spine and may have a rudimental fin; the minute teeth being either singly or triply cuspidate. The oldest representative of the family seems to be the extinct *Cyclobatis* from the Cretaceous rocks of Palestine, in which the disc is either circular or oval in form, the tail very short, only slightly projecting beyond the margin of the disc, and devoid of either spine or fin, while the upper surface of the body has one or more longitudinal series of large spiny tubercles running backward from the pectoral girdle, the remainder of the body and disc being more or less sparsely covered with minute prickles.

The Extinct Lobe-finned and Fold-finned Sharks — Orders *ICHTHYOTOMI* and *CLADODONTIA*

The whole of the preceding members of the subclass are included in a single order, the characteristics of which have been already described; but in the Paleozoic strata of both Europe and the United States there occur remains of extinct sharks, indicating two perfectly distinct ordinal groups.

Lobe-Finned Group

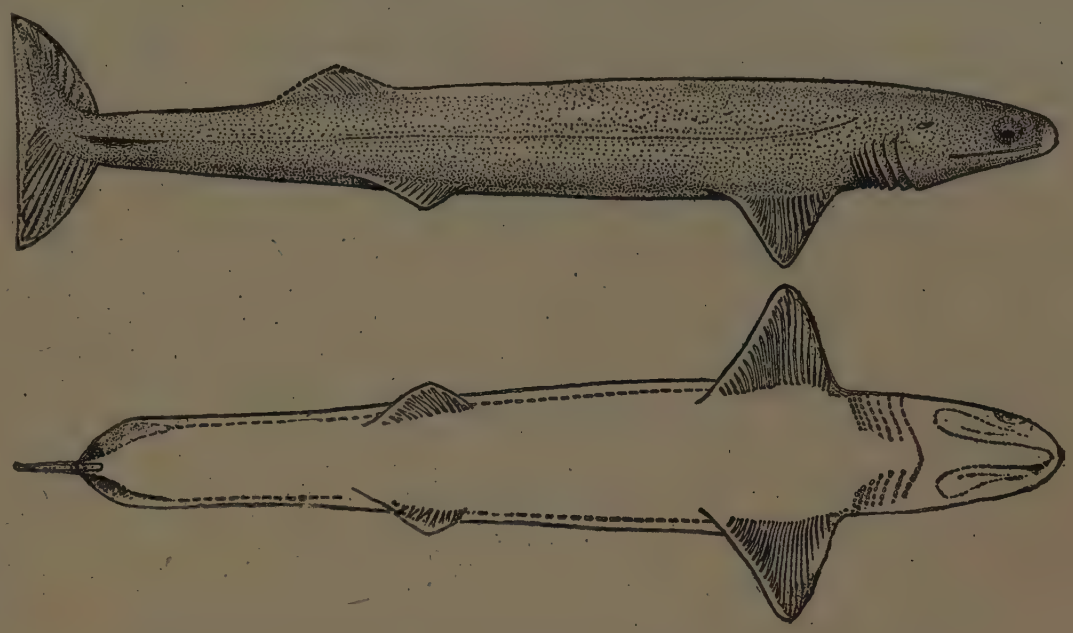
The essential characteristic of this group, as shown in the restored skeleton figured on p. 2685, is the lobed structure of the pectoral fins, which consist internally of a long tapering segmented axis, from which are given off a double series of cartilaginous rays, as shown in the figure on p. 2687. The internal skeleton of these sharks shows granular calcifications in the cartilage; but the notochord is never or but seldom constricted into distinct vertebræ, the calcification, except in the tail, stopping short at an incomplete stage, when the body of each segment of the backbone consists of three separate pieces, as in the example figured on p. 2680. The upper and lower arches and spines of the backbone are tall and slender; the upper spines having no intercalary cartilages between them. As represented by the genus *Pleuracanthus*, common to the Permian and Carboniferous rocks of both sides of the Atlantic, these sharks are further characterized by the slender and slightly-depressed form of the body, the terminal position of the mouth, and the diphycercal tail. The long and low dorsal fin is continued along the whole of the back from a short distance behind the head, and its cartilages are more numerous than the subjacent spines of the vertebræ; immediately behind the head is a long barbed spine, and the body was probably devoid of shagreen. The teeth, as shown in the annexed illustration, are very peculiar, consisting of two divergent and generally unequal-sized cones, supported on an expanded base.



TEETH OF A LOBE-FINNED SHARK.
(After Fritsch.)

Fold-Finned Group

The oldest and most primitive representatives of the entire subclass are the armored sharks of the Devonian and lower Carboniferous epochs, especially characterized by the simple structure of their fins, which, as explained on p. 2687, are of the fold type, and consist simply of a series of parallel cartilaginous rods arising from a broad base. In many, but not all of them, the granules constituting the shagreen of modern sharks coalesced so as to form large shields protecting the body; and these fish were also armed with more or less markedly triangular spines inserted in the skin by their bases. In some cases the teeth consisted of a single cone, with one small basal cusp; but in other forms they seem to have coalesced into a pavement-like structure. No traces of calcification have been detected in the notochord. As might have been expected these primitive sharks were of comparatively small size, averaging from three to four feet in length.



RESTORATION OF A FOLD-FINNED SHARK (*Cladoselache*).
(After Dean.)

The Extinct Spine-finned Sharks — Order *ACANTHODII*

Whereas the two preceding groups contain the most primitive and generalized representatives of the subclass, the order now to be considered , which is likewise confined to the Paleozoic epoch, comprises sharks of a more specialized type than any existing forms. Indeed, these spine-finned sharks bear much the same relationship to the lobe-finned group, as is presented by the bony fishes to the fringe-finned ganoids; and in a strictly natural arrangement these forms should stand at the head of the class, although it is more convenient to consider them in this place. One of the essential features of the group is to be



RESTORATION OF SPINE-FINNED SHARK (*Acanthodes*).
(From A. S. Woodward, *Cat. Foss. Fish. Brit. Mus.*)

found in the development of membrane bones overlying the original cartilaginous skull; the socket of the eye being also frequently surrounded with a ring of bones of similar origin. In the internal skeleton the notochord is persistent, and the cartilages are superficially calcified, frequently with a granular structure. When teeth are present, these are firmly fixed upon membrane bones overlying the cartilages corresponding to the functional jaws of other sharks. The gill arches bear a series of appendages which during life were probably furnished with membranous expansions similar to those of the existing frill-gilled shark. In the fins the cartilages of the internal skeleton are greatly reduced, and the membranous portions are almost destitute of cartilaginous rays; while each of the paired and most of the median fins are provided with a large spine on the front edge. The tail is of the heterocercal type, and the males lack the claspers characterizing the existing forms. Externally the body is covered with small and closely-arranged quadrangular granules, between two series of which runs the lateral line. Three families constitute the order; the first of these, as represented by the genus *Acanthodes*, having but a single dorsal fin; while in the other two — respectively typified by *Ischnacanthus* and *Diplacanthus* — there are two of these fins.

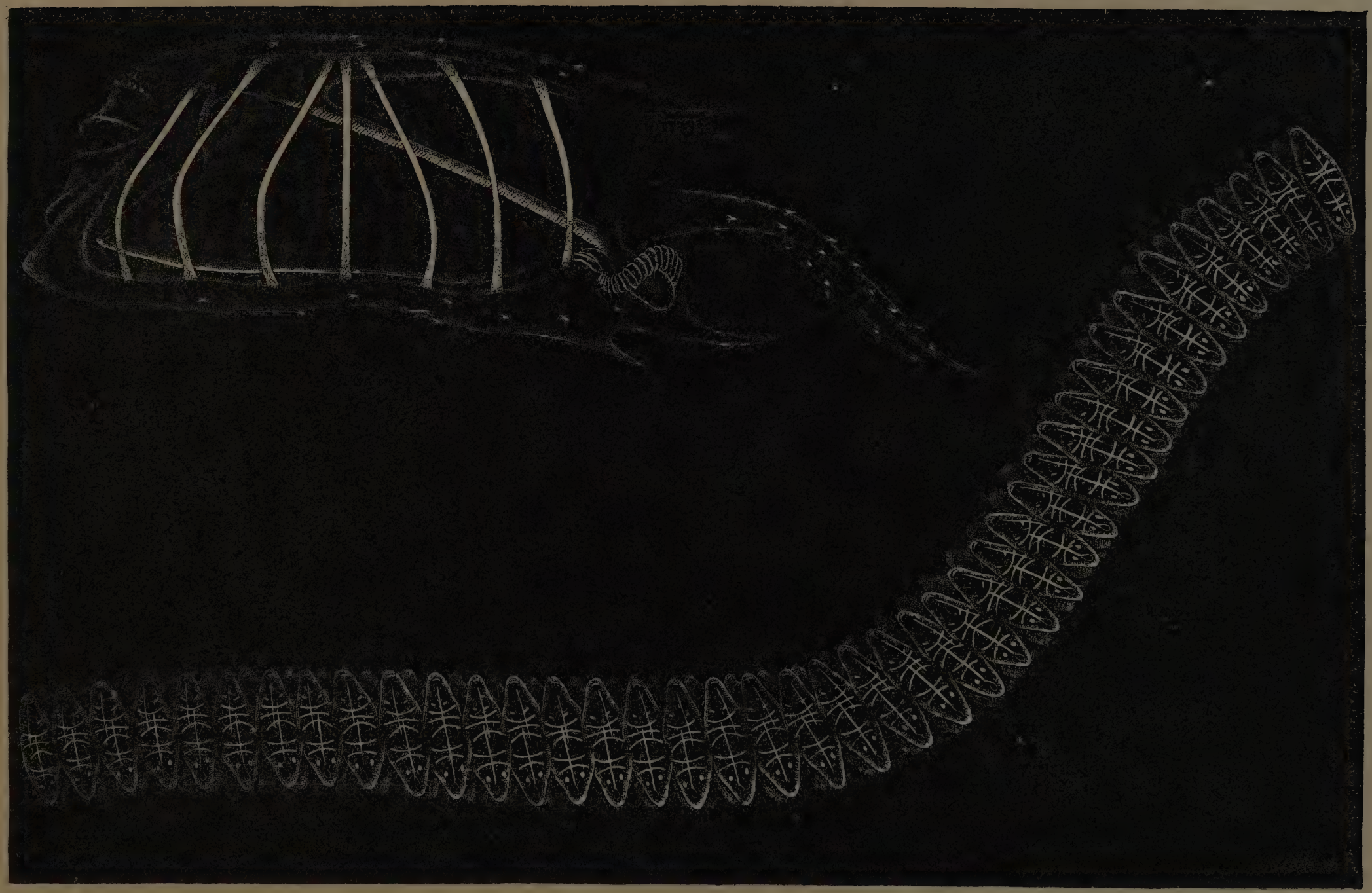
THE LOWEST VERTEBRATES AND THEIR ALLIES

CHAPTER I

THE LAMPREY GROUP — CLASS Cyclostomata

TILL within recent years both the lampreys and the strange little creature known as the lancelet were generally included among the class of fishes, which was also taken to comprise a number of armored extinct forms, of which a brief notice is given below. On the other hand, the marine animals commonly termed sea squirts, but technically known as ascidians, together with certain aberrant worm-like creatures, were classed with the great assemblage of so-called Invertebrates. Anatomical and palæontological investigations have, however, revolutionized our ideas concerning the creatures in question, with the result that while the lampreys are now separated from the fishes to form a class by themselves in the vertebrate subkingdom, the lancelet and sea squirts, together with the above-mentioned worm-like creatures are now regarded as forming a subkingdom by themselves, known as the Semivertebrates, or Protochordata. The reason for the separation of the lampreys from the fishes will be gathered when we come to that group; but we must briefly notice in this place the considerations which have induced naturalists to brigade in one group such very dissimilar creatures as the lancelet, sea squirts, and the aforesaid worms.

In the introduction to the Vertebrates given in the first volume we have indicated the leading structural features of that group — more especially as developed in its higher members; among these one of the most important being the dorsal position of the great nervous system, or spinal marrow, which in the higher forms is underlain by the bodies of the vertebræ. In our description of the fishes we have, however, seen that in some of the lower forms the vertebræ are represented only by the original cartilaginous rod known as the notochord, from which they are developed by constriction in the higher types. To this we have to add that in the earlier stages of their development all vertebrates possess gill slits, which persist in their original condition only in the fishes and lampreys. Now the result of anatomical investigations has been to show that the lancelet, sea squirts, and the aforesaid worm-like creatures agree with the Vertebrates in the possession of a dorsally-situated nervous system, of a notochord, and of gill slits; and thereby differ from all other known animals. Consequently we may classify the animal kingdom as follows:



ASCIDIANS.
Solitary Salpa and Chain Salpa.

I. CHORDATE ANIMALS — Division CHORDATA { Nervous System Dorsal; a Notochord, and Gill Slits.
   1. Vertebrates — Subkingdom VERTEBRATA.
      (1) Mammals — Class MAMMALIA.
      (2) Birds — Class AVES.
      (3) Reptiles — Class REPTILIA.
      (4) Frogs and Salamanders — Class AMPHIBIA.
      (5) Fishes — Class PISCES.
      (6) Lampreys and Hagfishes — Class CYCLOSTOMATA.
   2. Semivertebrates — Subkingdom PROTOCHORDATA.
      (1) Lancelets — Class LEPTOCARDII.
      (2) Sea Squirts — Class TUNICATA.
      (3) Worm-like Forms — Class ENTEROPNEUSTA.
II. NONCHORDATE ANIMALS — Division INVERTEBRATA { Nervous System Ventral; no Notochord or Gill Slits.

We shall consider briefly the suggestions that have been made concerning the relationships between the semichordates and nonchordates at the close of this volume, and therefore proceed at once to the lampreys. Before doing so it may, however, be as well to mention that to rightly understand the peculiarities of all these matters requires a considerable amount of anatomical knowledge on the part of the reader; and structural features will accordingly be alluded to as simply and shortly as possible.

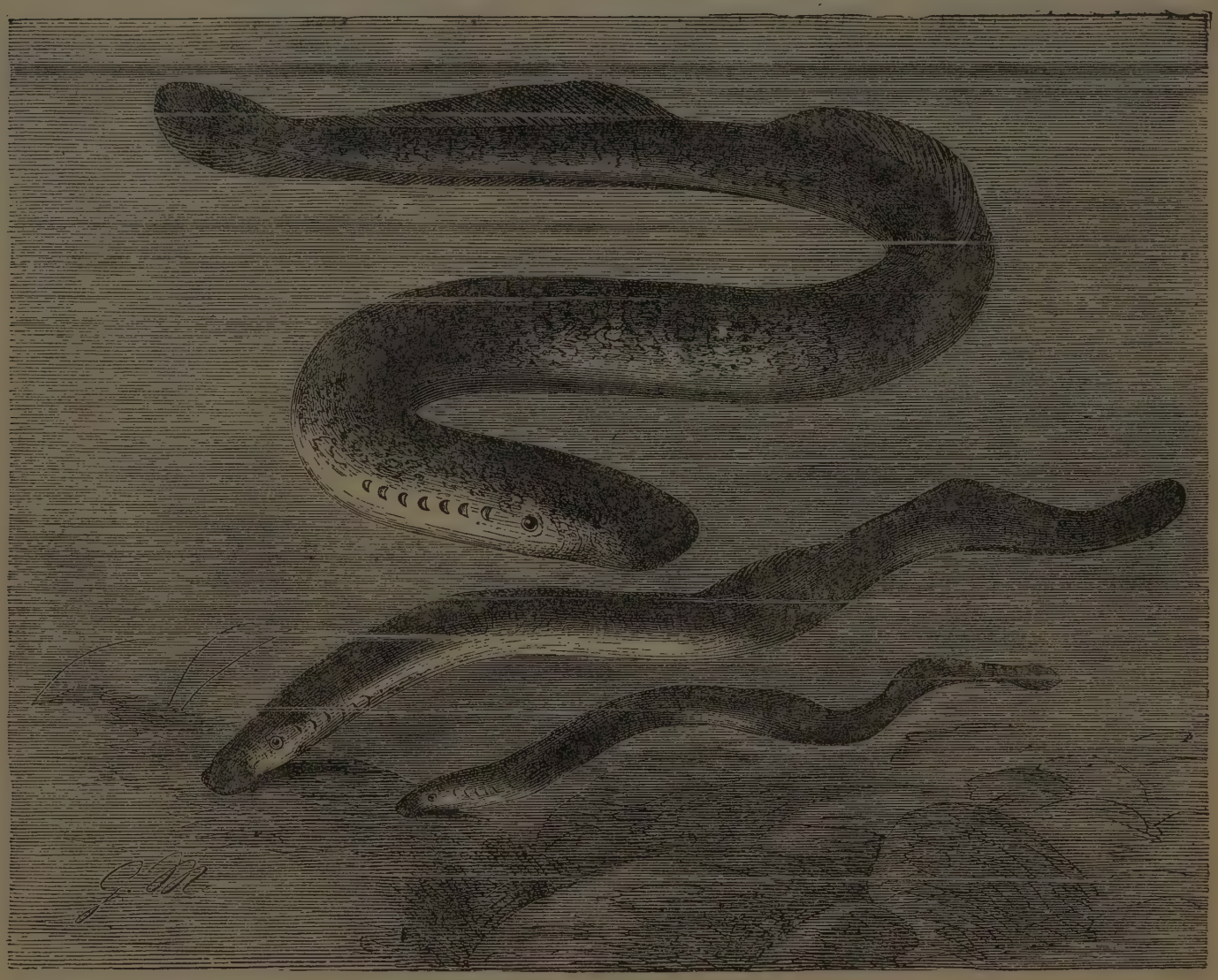
THE LAMPREYS AND HAGFISHES — SUBCLASS Marsipobranchii

As a class, the lampreys and their near allies the hagfishes, with which may probably be grouped certain armored extinct forms, are distinguished not only from the fishes, but likewise from all the vertebrates hitherto described, by the absence of true jaws, by the single aperture of the nostrils, as well as by the rasping tongue; there being no limbs or ribs, and the notochord either persisting in its original form or being merely surrounded by a series of calcified rings. Probably many or all of these characteristics are applicable to certain extinct forms now considered as more or less nearly allied to the lampreys, and we may accordingly provisionally regard these as distinctive of the subclass. On the other hand, we may consider the undermentioned features distinctive of the lampreys as the representatives of a subclass (Marsipobranchii), apart from the aforesaid extinct forms. In the existing members of the group the skeleton is cartilaginous; the skull, as in the chimæroid fishes and some of the sharks, is immovably joined to the vertebral column; and the gills are in the form of fixed pouches (hence the name of the subclass), without gill arches, and either six or seven in number, with their external apertures usually opening on the sides of the neck. Anterior in position, and adapted for sucking, the mouth is surrounded by a circular or subcircular lip supported by cartilages. The naked body is provided with median fins, having cartilaginous rays like those of many fishes. Internally, the heart is devoid of the anterior expansion known as the bulbus arteriosus; the intestinal canal is straight and simple; and the reproductive organs discharge into the cavity of the body. The place of teeth is taken in some forms

by horny structures, while in others the mouth is completely unarmed. Some difference of opinion exists among naturalists as to whether the absence of the true jaws in the lampreys is an original or an acquired feature; but, to our mind, the apparent want of these organs in the primitive extinct lampreys seems to be strongly in favor of the former view.

True Lampreys

The true lampreys, of which the sea lamprey (*Petromyzum marinus*), river lamprey (*P. fluviatilis*), and the small lamprey (*P. branchialis*) occur in Britain, are the typical representatives of a family (*Petromyzidæ*) characterized by the nasal duct terminating in a closed sac behind, without



SEA LAMPREY, RIVER LAMPREY, AND SMALL LAMPREY.
(One-fourth natural size.)

perforating the palate. As in all the other members of the group, the naked body is eel-like in form; but the family is peculiar in that its members undergo a metamorphosis, the young being devoid of teeth, and furnished with a single median fin, whereas in the adult the sucking mouth is furnished with horny teeth resting on a soft cushion, and the median fin is divided. In the adult the tongue is furnished with rasping teeth, while above and below the aperture of the mouth there are a series of upper and lower teeth, and the sucking disc is likewise provided with smaller isolated teeth. Eyes are present in the adult; and the aperture of the nos-

trils is situated in the middle of the head. The seven gill pouches open externally by as many apertures on each side of the neck, but communicate with the pharynx by a common opening to which the ducts of all converge. The intestine is furnished with a spiral valve, and the eggs are minute.

The true lampreys are characterized in the adult condition by having two dorsal fins, the hindmost of which is continuous with the caudal; and likewise by the upper series of oral teeth consisting either of a doubly-cusped transverse ridge, or of two closely-placed separate teeth; while the teeth on the tongue are serrated. The genus appears to be represented by four species, which are confined to the coasts and fresh waters of the Northern Hemisphere, ranging as far south as West Africa. The largest of these is the sea lamprey, represented in the upper figure of our illustration, which may grow to as much as a yard in length, and is common to Europe, North America, and West Africa. On the other hand, the river lamprey, or lampern, which at certain seasons ascends the rivers of Europe, North America, and Japan in innumerable hosts, is somewhat less than two feet in length, and differs from the last species in being uniformly colored, instead of marbled with black. Still smaller is the small lamprey, also known as the pride or sandpiper, which is likewise common to Europe and Western North America, and scarcely reaches one foot in length; its coloration being uniform. The young of this form was long regarded as a distinct genus, under the name of *Ammocœtes;* but its true nature was discovered by watching the transformation into the adult. The larva, writes Dr. Günther, requires three or four years for its full development. At first the head is very small, and the cavity of the mouth "surrounded by a semicircular upper lip, the separate lower lip being very small. There are no teeth, but several fringed barbels surround the mouth. The extremely small eyes are hidden in a shallow grove; but there is a median single nasal opening, and seven gill openings, as in the adult. The vertical fins form a continuous fringe, in which the later divisions are more or less distinctly indicated." When open, the mouth of lampreys is nearly circular in shape, but when closed forms a narrow slit.

Much has still to be learned regarding the habits of lampreys, but it appears that all the members of the present genus ascend rivers for the purpose of spawning, and that some of them pass the whole of their larval conditions in fresh waters. They are all carnivorous, and in the adult state attach themselves by their mouths, to the bodies of fishes, from which they rasp off the flesh with their horny teeth; fish being not unfrequently met with bearing the scars of wounds thus inflicted, and a salmon has been taken high up in the Rhone with a sea lamprey tightly adhering to its side. Bathers have also been known to be attacked by the same species. Commonly keeping to the bottom, the sea lamprey may at times be seen swimming near the surface with a serpentine movement of the body. In the Severn the capture of this species lasts from February to May, while in the Thames the season is May and June; but in the Scottish rivers the lampreys do not ascend till the end of June, remaining till the beginning of August. During the spawning season these fishes excavate furrows in the river bottoms for the reception of their eggs, and are said to remove impeding stones by lifting them up with their sucking mouths. Being much exhausted by the function of spawning, at its conclusion they make their way with

all speed to the sea. The river lamprey was at one time thought to be a permanent inhabitant of fresh waters, but it has been taken in the sea, and it has even been considered that it may undergo its metamorphosis in salt water. Always restricted to low-lying countries, this lamprey may be found alike in rivers, streams, lakes, and marshes, although it only spawns where the water is clear and flows swiftly over a stony bed. During the spawning season, which takes place in March and April, the lampreys acquire a brilliant metallic lustre; while at the conclusion of the function they generally perish. Formerly these lampreys occurred in enormous quantities in many of the English rivers, upward of three thousand having been taken at Newark in a single night; but the numbers in the Thames are now considerably diminished. Their chief use is as bait for cod and other fish; for which they are specially adapted on account of the ease with which they can be kept alive. There is nothing calling for special notice with regard to the habits of the small lamprey.

Southern Lampreys

In the Southern Hemisphere the family is represented by three genera, in one of which there is a single species (*Mordacia mordax*) common to the coasts of Chili and Tasmania; while in a second (*Geotria*) there is one Chilian and another South Australian species. The first of these two genera agrees with the typical representatives of the family in the continuity between the second dorsal and caudal fins, but differs in having two groups of three-cusped teeth above the aperture of the mouth; whereas in the second genus the two fins above mentioned are separate, and there is a four-lobed plate



HAGFISH.
(Three fifths natural size.)

above the mouth. Some of these lampreys grow to a length of a couple of feet; and in the adults of some or all of them the skin of the throat is so much expanded as to form a kind of pouch. The third genus (*Exomegas*) appears to be known only by two examples from the Atlantic side of South America, one of which was picked up in the streets of Buenos Ayres in 1867, while the second was obtained from the Bay of Monte Video in 1890. With the exception that the dentition is of a peculiar type, very little is known as to the structure of this rare form. It will not fail to be noticed that the remarkable geographical distribution of these southern lampreys is paralleled by that of certain fresh-water fishes already described, with

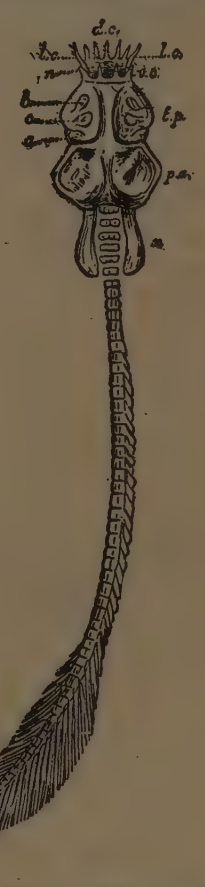
the exception that there is no instance among the latter where a species is common to Australia and South America.

Hagfishes

The hagfishes, of which there are two genera, constitute a family (*Myxinidæ*) distinguished from the last by the nasal sac having a posterior duct which perforates the palate; the single external nasal aperture being situated above the mouth at the extremity of the head, which is furnished with four pairs of barbels. The mouth is devoid of lips, the palate is provided with a single median tooth, and there are two comb-like series of rasping teeth on the tongue. The gill apertures, or aperture, are situated at a considerable distance from the head; and each gill pouch has a separate duct opening into the œsophagus. The sides of the abdomen carry a row of mucous sacs, and there is no spiral valve to the intestine. The large eggs are invested in a horny envelope, furnished with threads for adhesion. In the true hagfishes, of which the common species (*Myxine glutinosa*) is found on the coasts of Europe and North America, there is but a single gill opening on each side of the abdomen, leading by means of six ducts to as many gill pouches. Another species has been recorded from the extremity of South America; and the range of the genus also includes Japan. In the second genus (*Bdellostoma*), of which there are two species from the coasts of the South Pacific, there are six or more gill openings on each side, each communicating by a separate duct with a gill chamber. All these creatures are marine, and are frequently found deeply buried in the bodies of fishes, more especially members of the cod family, into which they bore for the purpose of feeding on the flesh. They are totally blind, and secrete vast quantities of slime, which seriously interferes with fishing in localities where these creatures abound. Met with in the fjords of Norway at a depth of about seventy fathoms, hagfishes have been dredged from depths of nearly three hundred and fifty fathoms.

Primeval Lampreys

The Old Red Sandstone of Caithness has yielded the skeletons of a small limbless creature (*Palæospondylus*), which there is little doubt must be regarded as one of the forerunners of the modern lampreys. Measuring only about a couple of inches in length, these skeletons show a well-calcified skull, while the notochord is surrounded by a series of calcified rings, and the tail has a large fin, of which the supports on the upper side are forked like those of lampreys. The front of the head has a circular opening surrounded with a ring of tentacles (*dc*, *lc*), probably corresponding to the nose of a modern lamprey; the opening of the nose itself (*n*) appears to be single and there are a pair of plates (*x*) behind the head not improbably representing gill plates. It may be confidently assumed that this little creature is but one among a series of lost types.



SLIGHTLY ENLARGED RESTORATION OF THE SKELETON OF THE PRIMEVAL LAMPREY.
(After Traquair.)

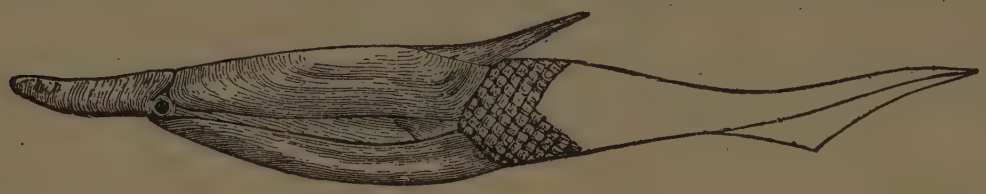
CHAPTER II

THE ARMORED PRIMEVAL VERTEBRATES — SUBCLASS OSTRACOPHORI

A GROUP of remarkable armored forms from the Paleozoic rocks formerly placed among the fishes, are now regarded as probably constituting a subclass of the class typically represented by the lampreys, although it must be confessed that we have at present no evidence of the links which, on this view, must be supposed to have connected the two groups. Strange in form, and utterly unlike any living animals, these primeval armored vertebrates are characterized by the great development of the external skeleton, the head and fore part of the body being protected by large bone-like plates. There are no hard structures to the mouth, and there are, at most, but rudimental indications of arches for the support of limbs, while the notochord is persistent. They may be divided into three chief groups; and one of the most curious features connected with the first of these is the apparent structural identity of one layer of its shield with a layer found in the investment of the living king crabs.

Pteraspis

The simplest of these armored forms is typified by the genus *Pteraspis* of the Devonian rocks, a partial restoration of which is given in the annexed figure. In these creatures the head and fore part of the body are protected both above and beneath by shields; while the tail, in some cases at least, is scaled. The structure of the shield is curious, each plate consisting of an outer and inner hard layer, between which is a thick stratum of polygonal chambers, perforated by delicate tunnels of the sensory canal system of the skin; all the layers lacking the elements of true bone, and the outer surface being marked with fine concentric striæ. The eyes are lateral and widely separated, and toward the hinder end of the back shield (which is provided with a spine) there is an aperture on each side for the escape of water from a gill cavity. Although nothing is known as to the form and structure of the nose and mouth, the nostrils must evidently have been placed near the mouth on the under surface of the head. A pit between the eyes probably marks the site of a rudimental median eye; and the structure of the under surface of the shield indicates the presence of separated gill pouches, which were probably supported by arches. From an examination of the whole structure of the remains, Mr. A. S. Woodward is of opinion that the

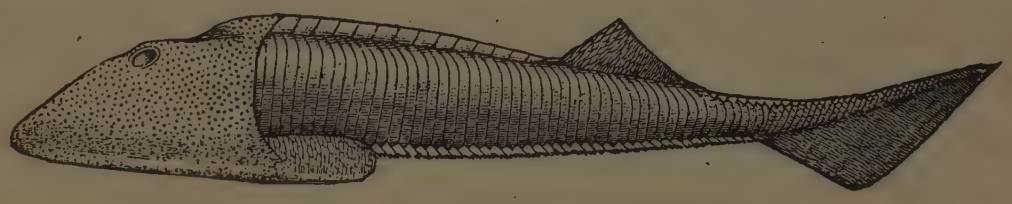


PARTIAL RESTORATION OF *Pteraspis*.
(From A. S. Woodward, *Cat. Foss. Fish. Brit. Mus.*)

shield probably covered "a truly fish-like head; and if it was not for the invariable absence of limbs and jaws, and the forward position of the breathing apparatus in *Pteraspis* and its allies, these animals might be placed, without hesitation, in the class of fishes. The possibility that limbs and jaws were present, but not calcified enough to be preserved, must, however, be borne in mind; while the negative evidence on this subject, and the want of information as to the nature of the tail, are factors necessitating caution in the determination of affinities."

Cephalaspis

The next family of the group is typified by the genus *Cephalaspis*, in which the front shield appears to be confined to the head and gill region, and consists of a single piece, rounded or pointed in front, abruptly truncated behind, and with the rounded margin bent inward below to form an ornamented flattened rim. Of the triple-layered shield, the inner layer is bony, the thick middle one solid, although traversed by a network of blood vessels, while the upper one is tuberculated and resembles teeth in structure. The eyes are placed close together in the middle of the shield, the nostrils must have had much the same position as in *Pteraspis*, and at the back of the shield there occurs on each side a small flap which must be regarded as a gill cover. Immediately behind the shield commences the ordinary scaling of the body, without any signs of arches for the support of limbs. Paired fins appear, indeed, to be totally absent, although a dorsal and a caudal fin, stiffened by little elongated scales in place of rays, are present. The large, deep, quadrangular scales covering the body form a series of interlocking rings, doubtless corresponding in the living state to the underlying muscle plates of the body.

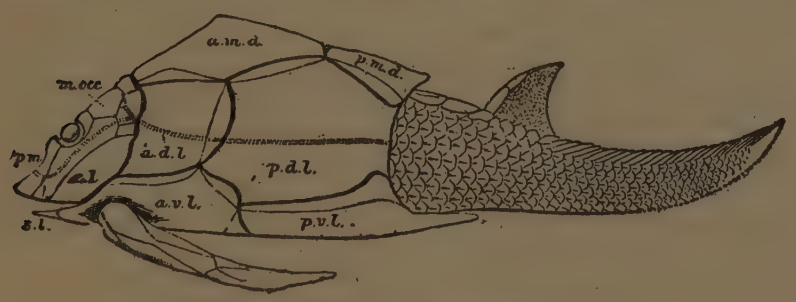


RESTORATION OF *Cephalaspis*.

(From A. S. Woodward, *Cat. Foss. Fish. Brit. Mus.*)

Pterichthys

The third modification of the group, as represented by the Devonian *Pterichthys*, agrees in the general structure of the shield with certain members of the last section in which there is no dividing line between the head shield and the united scales of the body. The head is, however, sharply defined from the body; and the armor, instead of being simple, consists of a number of overlapping plates arranged symmetrically to one another. An important point of distinction from all the preceding forms is to be found in the presence of a pair of hollow limb-like pectoral appendages, jointed near the middle. A small movable plate between the eyes seems to have lodged a median eye; another movable plate on the cheek appears to represent the gill cover; and a pair of loose jaw plates on the lower surface of the front of the head, in some forms at least, are finely toothed on the hinder border; but nothing



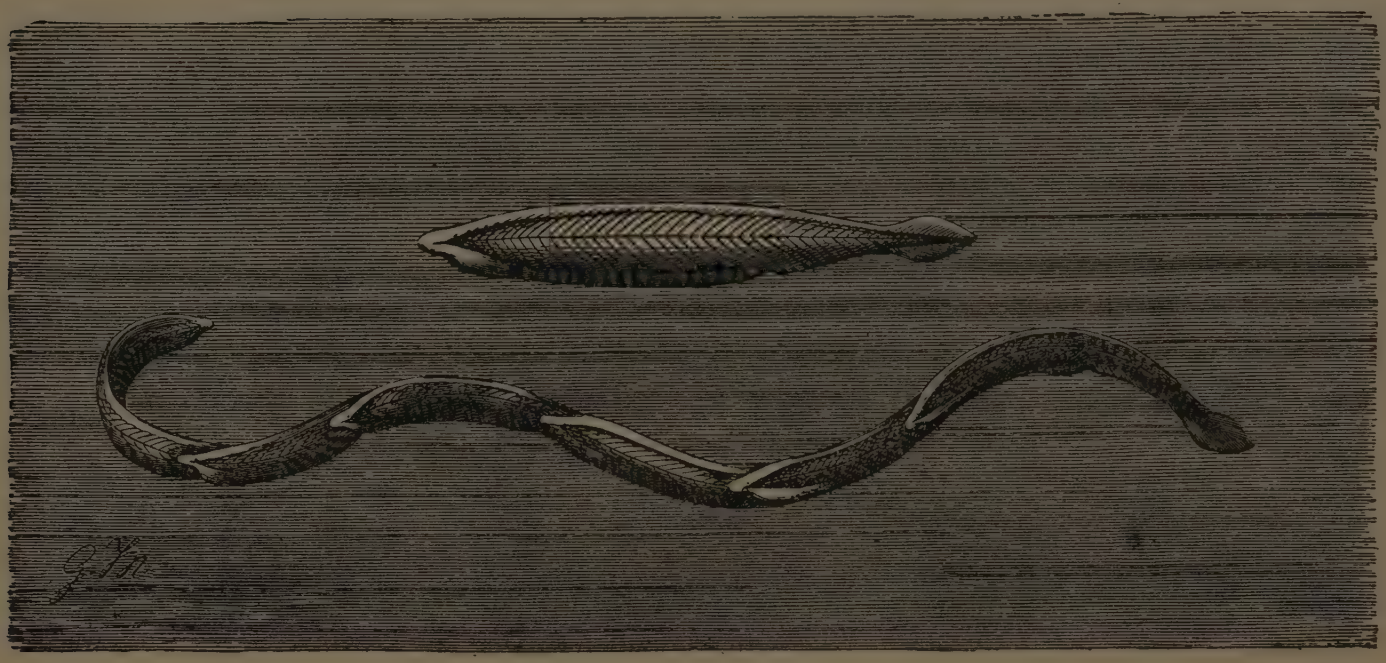
RESTORATION OF PTERICHTHYS.

(From Traquair.)

definite is known with regard to the nature of the nose, mouth, and jaws. The arrangement of the median fins is generally similar to that obtaining in the second family. With regard to the true nature of the pectoral appendages, Mr. Woodward writes that they are commonly considered "as homologous with the paired pectoral fins of fishes, and certainly in their mode of fixation to the trunk there is much to favor that supposition; but the discovery of an allied organism in the Devonian of Spitzbergen suggests the wisdom of suspending judgment. The dorsal body shield of the latter is simpler than that of *Pterichthys*, but the arrangement of the plates on the ventral aspect is identical, and there are also hollow pectoral appendages. These appendages, however, are merely simple triangular spines, firmly fixed by suture to processes of the body armor; and if they are an inferior or special condition of the ordinarily movable arms, it seems not unlikely that those arms will prove to be different in origin from the paired limbs of fishes."

CHAPTER III

THE LANCELETS — Subkingdom PROTOCHORDATA
Class Leptocardii



COMMON LANCELET, SINGLY, AND IN A CHAIN.
(Natural size.)

WITH the curious semitransparent little creatures known as lancelets, forming the only family (*Branchiostomatidæ*) and genus of the class to which they belong, we leave the Vertebrates and come to the lower group of Protochordates; all of which retain the three essential vertebrate features mentioned on p. 2925. First described by the German naturalist Pallas in 1778, from a specimen captured on the Cornish coast, the common lancelet (*Branchiostoma lanceolatum*) was referred to that refuge for the destitute, the Molluska, where it remained till 1834, when it was rediscovered by Costa, on the Neapolitan coast, who gave the name of *Branchiostoma*, and placed it among the fishes, in the neighborhood of the lampreys and hags. It was again discovered by Yarrell in 1836, who assigned the title of *Amphioxus*, and was the first to recognize the existence of a cartilaginous vertebral column, or notochord. The upper figure of our illustration shows the pointed extremities of the body, and also a number of chevron-shaped lines, with their angles directed forward, these being the partitions dividing the longitudinal mass of muscle clothing each side of the body into a series of segments. And it is due to this segmented structure that the lancelet is enabled to swim so speedily as it does, its progress being effected by serpentine movements of the body. Paired fins are wanting; but the back is

provided with a continuous dorsal fin, expanded posteriorly into a caudal fin, and continued forward to join the ring of feelers, or tentacles, growing from the margin of the hood-like expansion of skin which surrounds the mouth. The notochord extends to the anterior and posterior extremities of the body, reaching beyond the muscle plates, and likewise in advance of the front extremity of the overlying nerve chord; the latter feature being peculiar to the lancelet. An aperture distant about two-thirds of the whole length from the head, and opening in the middle line of the lower surface of the body, is the outlet of a large cavity, or atrial chamber, surrounding most of the internal organs, and especially the large pharynx; and the vent, as in many tadpoles, is situated high up on the left side, near the hinder end of the body. The reproductive organs, which form oval structures lying below the muscle plates, differ from those of the Vertebrates in that they consist of a large number of perfectly distinct chambers, corresponding to the muscle segments of the region of the body along which they extend. In connection with the fins, it should be observed that, except at its two extremities, the dorsal fin is supported by a series of gelatinous rays, each lying in a chamber of its own; while the ventral portion of the caudal fin has a paired series of similar supports. In young and transparent examples, the pharynx, or that portion of the alimentary tract immediately behind the mouth, is distinctly visible through the walls of the body, and can be seen to be perforated on each side by a very large number of vertical gill slits, opening into the atrial chamber. In the living creature an almost continuous current of water is drawn, for the purpose of breathing and feeding, through the mouth into the pharynx, whence it escapes by means of the gill slits into the atrial chamber, from which it is discharged through the pore. Unlike even the lowest Vertebrates, lancelets have no cartilaginous skull; the only solid structure in the head taking the form of a ring of cartilage in the hood surrounding the mouth, which gives off a series of processes for the support of the feelers. Although paired eyes, as well as organs of hearing, are totally wanting in these strange little creatures, a pigment spot at the front end of the nerve tube represents a median eye; behind which is a small nasal pit, communicating in the larva by means of a small pore with the front of the nerve tube. With regard to the other soft parts, it will suffice to mention that the anterior extremity of the nerve tube is not expanded to form a true brain; and that the heart is represented merely by a series of pulsating dilatations of the great blood vessel; the blood itself being devoid of color.

Lancelets are represented by some eight or nine species, all of which may be included in a single genus; although one from the Bahamas is peculiar on account of the unsymmetrical arrangement of its reproductive organs. Essentially littoral forms, inhabiting shallow water, especially where the bottom is sandy, these creatures have an almost universal distribution on the temperate and tropical coasts, although they are often curiously local. The European form has been recorded from Scandinavia, Heligoland, the English Channel, France, the Mediterranean, and Chesapeake Bay, growing to an unusual size in French waters. Other species occur on the Atlantic and Pacific shores of North and South America, as well as on the coasts of Australia, Japan, Ceylon, and the Fiji islands. Mr. A. Willey remarks that the lancelet "possesses an extraordinary capacity for burrowing in the sand of

the seashore or sea bottom. If an individual be dropped from the hand on to a mound of wet sand, which has just been dredged out of the water, it will burrow its way to the lowest depths of the sand hillock in the twinkling of an eye. Its usual *modus vivendi* is to bury the whole of its body in the sand, leaving only the mouth with the expanded buccal cirri [tentacles] protruding. When obtained in this position in a glass jar, a constant inflowing current of water, in which food particles are involved, can be observed in the neighborhood of the upstanding mouths. The food consists almost entirely of microscopic plants (diatoms, desmids, etc.) and vegetable débris. . . . Occasionally it emerges from its favorite position in the sand, and after swimming about for some time it will sink to the bottom, and there recline for a longer or shorter period upon its side on the surface of the sand. When resting on the sand, it is unable to maintain its equilibrium in the same position as an ordinary fish would do, but invariably topples over on its side, — indifferently, the right or left;'' this inability to maintain its balance being due to the absence of certain structures of the internal ear, to which this function is assigned in fishes. According to another observer, lancelets occasionally attach themselves to another by their mouths in a chain-like manner, as represented in our illustration. That lancelets indicate an extremely archaic type, and also that they are more nearly allied to the Vertebrates than to the Invertebrates, may be considered certain; although there is still a difference of opinion whether they should be looked upon as simple or degraded forms.

CHAPTER IV

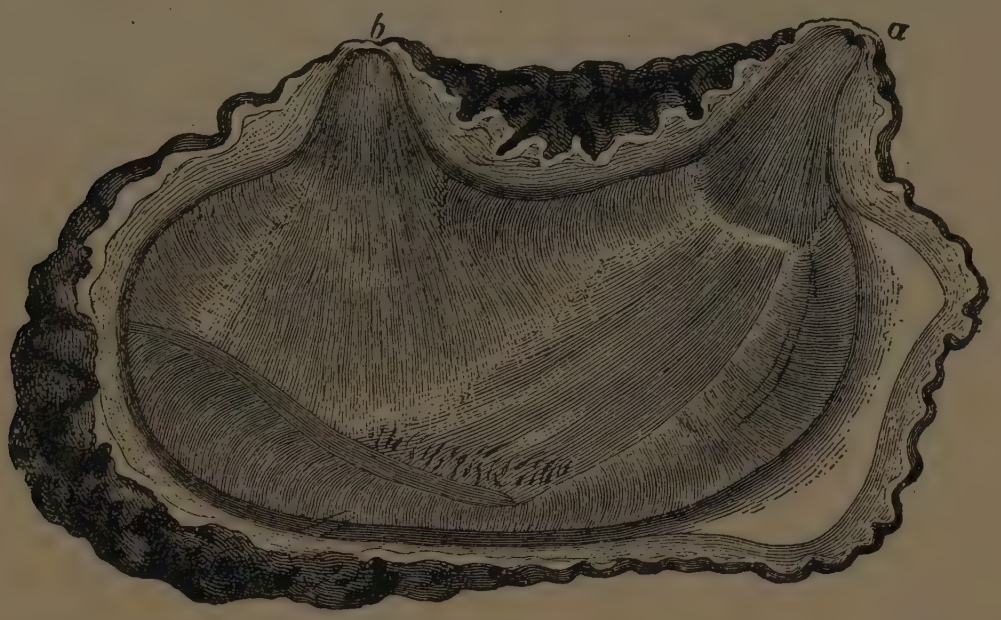
THE SEA SQUIRTS OR ASCIDIANS — CLASS *Tunicata*



A LEATHERY FIXED SEA SQUIRT, *Microcosmus*.
(Natural size.)

EXTERNALLY, scarcely any creatures are more unlike the lancelet than those fixed marine animals commonly known as sea squirts, and technically as ascidians, or tunicates. Nevertheless, in the opinion of those best qualified to judge, the relationship is probably closer than that existing between the former animal and the larva of a lamprey, in spite of the much greater external resemblance between the two latter. It is, however, when we dissect a sea squirt that we meet with structures recalling certain features in the anatomy of the lancelet; while to find evidence of the chordate affinities of the former, we have to go back to its larval condition. In the adult condition, writes Mr. Willey, most of the sea squirts "are sedentary animals, remaining fixed for their lifetime on one spot, whether attached to rocks, stones, shells, or seaweeds, from which they are incapable of moving. There are, however, several very extraordinary genera of ascidians, which swim or float about

perpetually in the open ocean, and have become adapted in the extremest manner to a purely pelagic environment." As there are both simple and compound fixed ascidians, so there are two similar types among the pelagic forms; but some of the latter are complicated by an alternation of generations, the one generation being a simple form, whereas in the other generation the units are aggregated into chains, as shown in our plate of the creatures known as salpæ. Among the compound fixed types the colonies, as they are termed, consist of a number of individuals produced by budding from a single parent stock; such colonies frequently attaining very large dimensions, and being remarkable for their brilliant coloration, although in other cases they merely form thin incrustations on the surface of various marine objects. Other forms, on the contrary, are merely connected at their bases by a common creeping root-like base, from which new buds are from time to time given off, the individuals being otherwise free.*



A LEATHERY SEA SQUIRT, WITH ONE SIDE OF THE OUTER TUNIC REMOVED.
(Natural size.)

Structure of Ascidians

Externally a simple sea squirt, like the one (*A. microcosmus*) represented in the first illustration, has been aptly compared to a leather bottle with two spouts; these spouts forming funnel-shaped projections, one of which — generally situated at a higher level than the other — takes in water, which is discharged from the second. The whole organism is invested in an external tunic, varying much in structure, but being frequently warty, and generally opaque, although in the salpæ it is transparent. A remarkable feature connected with this outer tunic is that it contains a substance — cellulose — identical in composition with that forming the cell walls of plant tissues. On cutting through the outer tunic, we come, as in our second illustration, to an underlying muscular tunic, forming the true body wall, and consisting externally of an epidermis underlain by interlacing muscular fibres. In the illustration, *a* indicates the inhalent, and *b* the exhalent orifice of this inner tunic. On cutting into the inner tunic, we find a large

*Strictly speaking, the term "individual" includes all the units produced by budding from a common stock, but it is more convenient to use it in the ordinary sense.

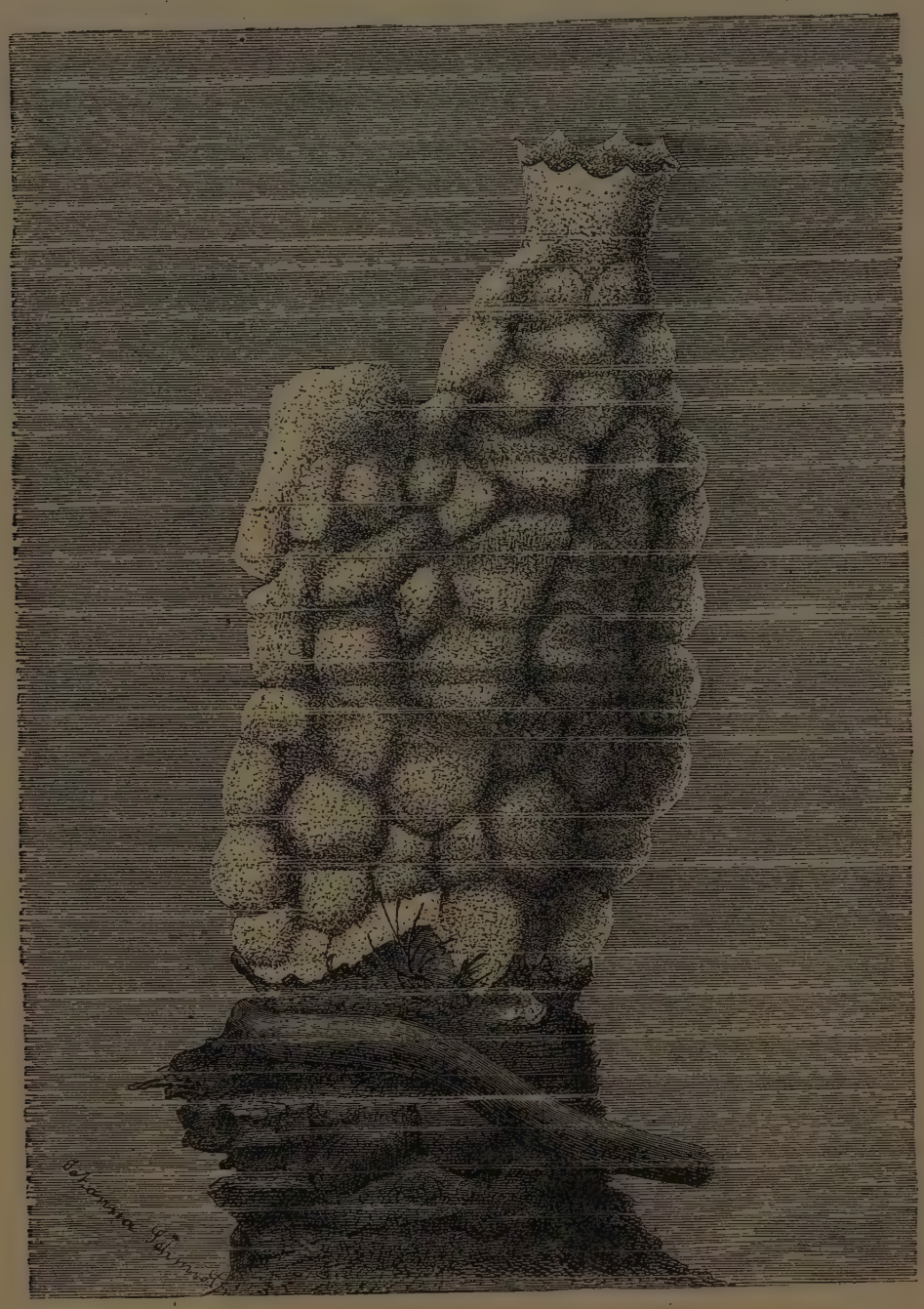
so-called atrial cavity, inclosing to a great extent the viscera, and communicating with the exterior by means of the exhalent orifice. The inhalent orifice, or mouth, communicates, on the other hand, directly with the exceedingly large pharynx or branchial chamber, which extends nearly to the hinder end of the body, and is perforated by a vast number of gill openings, through which the water taken in at the mouth passes into the atrial chamber. Instead of passing directly into the latter chamber with the water, the food is caught up in a mass of slime, and carried round the base of the mouth tube until it reaches the entrance to the œsophagus, which lies near the hinder end of the dorsal surface of the branchial chamber. Hence it passes into the stomach, and along the intestine, which forms a U-shaped curve turned away from the dorsal aspect; the vent opening on the same aspect into the atrial cavity below the exhalent orifice. With regard to the nervous and circulatory system, it will suffice to say that there is a large nerve ganglion embedded in the tissue of the inner tunic, and lying on the dorsal surface of the body between the inhalent and exhalent orifices; and true blood vessels are wanting, the blood merely flowing through a series of spaces in the muscles and other tissues of the body and between the viscera, and the heart forming a dilated tube. Unlike the higher Chordates, all the ascidians are hermaphrodite; the reproductive organs frequently lying within the loop of the intestine, and discharging into the atrial cavity along side of the vent. A remarkable physiological feature of the group is to be found in the periodical reversal of the action of the heart; the blood being driven for a certain time in one direction, after which the heart makes a short pause, and then propels it in an opposite course.

In addition to certain other structural features, into the consideration of which it would be impossible to enter in a work of the present nature, the essential resemblance between the adult sea squirts and the lancelets is to be found in the possession by both of a pharynx perforated by a large number of gill openings, which convert it into a branchial chamber, opening into an atrial cavity instead of directly to the exterior. Several of the differences between the two, such as the hermaphrodite reproduction and the bent intestine of the sea squirts, are probably due to their sessile habits, since such features are characteristic of most fixed organisms. Other points of difference are to be found in the absence of segmentation, and the want of a dorsal nerve tube and notochord in the adult ascidian, although, as we shall see, a remnant of the latter exists in the tail during the larval condition.

Development

All ascidians, whether fixed or free in the adult condition, go through a free-swimming larval stage, during a part of which they develop a tail containing a notochord and nerve tube; and as this feature is all important from a morphological point of view, it must be mentioned here, although necessarily in a very brief manner. Generally the larval condition lasts but a short time; and this may be the reason for the development of the tail, as a powerful swimming organ would seem to be essential in order to enable the creature to reach a spot suitable for its permanent existence. During its development a groove makes its appearance on one surface of one ascidian embryo, the large cells on the side of which grow inward so as to inclose a tube, corresponding to the nerve tube of Vertebrates, beneath which is the notochord. When of an oval shape, and while still contained

in its investing membrane, the embryo assumes a ventral curvature, and at the same time produces a long tapering tail, which eventually becomes coiled round it. In addition to certain other structures, this outgrowing tail includes the nerve tube and the notochord; and in some forms contains the only muscles developed at all. Subsequently a rudimentary brain, corresponding to a simple structure in the lancelet, makes its appearance; and likewise an unpaired eye, agreeing precisely in



A CARTILAGINOUS FIXED SEA SQUIRT, *Phallusia*.
(Natural size.)

structure and mode of development with the rudimental median eye of the tuatera. After certain other changes, among which the development of a stomach and intestine are included, the larva is ready to burst from its membranes, which it does by spasmodic jerkings of the tail; and it thereupon starts on a free-swimming existence. Before long the cellular structure of the notochord in the tail begins to disappear by the formation of vacuities; and eventually the whole structure becomes filled with

gelatinous matter. After a brief free existence it fixes itself by its muzzle to some submarine object, with the tail stretched out and generally motionless. In a short time this appendage commences to shorten, and finally disappears, by being drawn up into the body of the developing sea squirt and absorbed. A further process of development results in the production of the perfect sea squirt; but it would be quite foreign to the scope of this work to enter into the details of the metamorphosis; and we may conclude this portion of our subject by stating that ascidians are probably



PEAR-SHAPED ASCIDIAN, *Hypobythius*.
(One-twelfth natural size.)

the degenerate descendants of permanently free-swimming forms provided with a complete notochord and nerve tube; both of which structures are now in most cases only temporarily retained in the tails of the larvæ.

According to the classification adopted by Professor Herdman, the tunicates may be divided into three orders, the first of which is known as the Ascidiacea. This group includes both fixed and pelagic, simple and compound types, none of which are provided in the adult state with a tail and retain no trace of a notochord; the

Typical Ascidians

free swimming forms constituting colonies, and the simple types being generally fixed. The outer tunic is permanent and well developed, generally increasing with the age of the individual; and the muscular structure of the inner tunic takes the form of an irregular network, and never of hoop-like bands. The walls of the large branchial chamber are perforated by numerous slits, opening into a single atrial cavity, which in turn communicates with the exterior by means of the exhalent aperture of the tunic; the vent opening into the atrial cavity. Many of the forms reproduce their kind by budding, and in most the sexually produced embryo develops into a tailed larva. The order is divided into three subordinal groups, of which the first — Ascidiæ Simplices — includes fixed (rarely unattached, but never free swimming) and generally solitary forms, which very rarely reproduce by budding. When colonies occur, each of their individual members has a distinct outer tunic of its own, the whole society never being buried in a common investing mass. Four families are contained in this suborder, each represented by a large number of genera. Omitting mention of the first family, we may take as an example of the second (*Cynthiidæ*) the genus *Microcosmus*, of which specimens are shown in the figures on pp. 2938, 2939. As a family, these sea squirts are characterized by being usually attached, and sometimes stalked, although rarely free. The outer tunic is generally membranous or leathery, but occasionally cartilaginous or covered with sand; while the inhalent aperture is usually, and the exhalent aperture invariably, provided with four lobes, meeting at the centre. The branchial chamber is longitudinally folded, with its gill slits straight; and the tentacles may be either single or compound. In the figured genus the body is attached and sessile, and the tunic, which is not incrusted with a continuous coat of sand, is thin, leathery, and tough; both its apertures having four lobes, and the tentacles being compound. As an example of the family *Ascidiidæ* we may take the well-known *Phallusia mammillata* from the seas of North-western Europe and the Mediterranean, which is shown in the illustration on p. 2941, and is the sole representative of its genus. In the family to which it belongs the body is attached and usually sessile, although rarely stalked; the inhalent aperture generally has eight, and the exhalent six lobes; and, as a rule, the outer tunic is either gelatinous or cartilaginous, although it may be horny. The branchial chamber is devoid of folds, with the gill slits either straight or curved; and the tentacles are simple and thread-like. In the figured genus the body is erect and attached, and the outer tunic of a cartilaginous nature; its surface being mammillated in a very characteristic manner. It may be mentioned here that all the simple sea squirts of this group, when touched, emit a jet of water; and that some of them, like the one figured on p. 2938, are used as articles of food. To the same subfamily as *Phallusia* also belongs the extensive genus *Ascidia*, in which the outer tunic is soft and flexible, instead of being cartilaginous. A totally distinct subfamily is, however, indicated by the remarkable deep-sea genus *Hypobythius*, of which the two known species were obtained at depths varying from six hundred to two thousand nine hundred fathoms, during the voyage of the *Challenger*. Here we find the cup-shape or pear-like body attached by a longer or shorter stem; while the apertures are circular and not closed by lobes. The outer tunic is cartilaginous,

but soft and thin, although thickened in places to form plates. The internal longitudinal bars usually found in the branchial chamber are wanting in this genus; the gill slits are small and irregularly placed; and the viscera form a compact irregular mass on the dorsal side of this chamber. In the species figured (*H. calycodes*), which is from the North Pacific, the stem is of great length, and the outer tunic thickened so as to form a number of nodules or plates; but in the South Atlantic form (*H. moseleyi*) the stem is much shorter, and there is only a single plate, situated on the dorsal side. Of very large dimensions, these deep-sea ascidians are decidedly the most beautiful members of the class, and present some resemblance to the glass sponges. A totally different type of structure is presented by the last family (*Clavelinidæ*) of the suborder, in which the body of each individual is attached by its posterior end, and usually by means of a stalk, to a creeping basal stolon, or common mass, from which young individuals are produced by budding. The outer tunic, which is usually thin and transparent, is in most cases gelatinous, although occasionally cartilaginous; and its circular apertures are but seldom distinctly lobed. Folds are wanting in the branchial chamber, but longitudinal bars may be present, although these lack the papillæ found in the preceding family; and the gill slits are straight. The tentacles resemble those of the last family in their simple, thread-like form; but the digestive tract is usually extended behind the branchial chamber to form an abdomen. In addition to the ordinary sexual reproduction, colonies may be formed by budding from the common stolon. Ten genera are included in the family, from among which the typical *Clavelina* is selected for illustration. Here the body is elongated and club shaped, but with no peduncle beyond the abdomen, and is attached to a delicate, branched, creeping stolon, from which arise the buds. The thin outer tunic is gelatinous or cartilaginous, with its circular apertures devoid of lobes. The inner tunic is likewise thin, with its muscles mainly longitudinal; and the intestinal tract is extended to form a well-marked abdomen. In its restricted sense, the genus includes only half a dozen small species from Northwestern Europe and the Mediterranean; the one here figured (*C. lepadiformis*) being characterized by the yellow or brown lines on the region known as the thorax.



A CREEPING ASCIDIAN, *Clavelina*.
(Natural size.)

The second suborder of the typical sea squirts—Ascidiæ Compositæ—includes fixed forms which reproduce by buds so as to constitute colonies in which the individuals are buried in a common investing mass, and thus possess no separate tunics. The group includes seven families; and Professor Herdman remarks that as many of these have originated independently from simple forms, the whole assemblage is to a certain extent an artificial one. In the first family (*Botryllidæ*) the colonies as shown in the illustration on p. 2945, usually form thin incrustations on seaweeds or stones, although they occasionally take the shape of thick fleshy masses; the individuals being arranged so as to form either circles or ellipses, or in

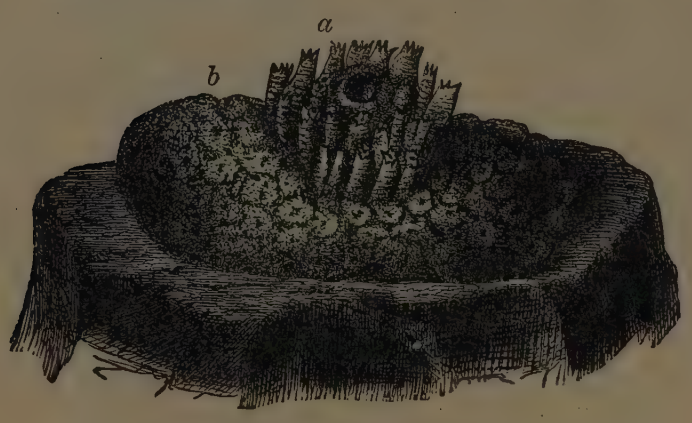
branching lines. The common apertures of discharge are distinct, and usually furnished with lobes; the individual units are short and show no division of the body into regions; and the outer tunic, which is usually soft, is traversed by numerous vessels with large terminal knobs. Internal longitudinal bars are present in the large and well-developed branchial chamber, in which the gill slits are numerous; and the simple tentacles do not exceed sixteen in number. Budding may take place either from the sides of the units constituting the colony or from the vessels in the tunic. Among the five genera constituting the family, the typical *Botryllus* (figured on p. 2949) has the colony thin and incrusting, with the individuals arranged in a circular manner, whereas in *Botrylloides* they form ellipses or branching lines. In the figured species of the latter (*B. albicans*) from Northwestern Europe and the Mediterranean, the colony is pure white in color, but in some it is purple with yellow or green markings, and in others yellowish green. As an example of forms in which the colony is thick and massive, we may cite the genus *Polycyclus*. Passing over the second family of the suborder, we come to the third (*Polyclinidæ*), in which the colony is usually massive, being sometimes incrusting, but in other cases lobed, or even stalked. The arrangement of the individuals is highly variable; and the common apertures of discharge are usually inconspicuous. Although of an elongated form, the individuals usually differ from those of the family last noticed by being divided into three regions; the inhalent aperture having six or eight lobes, while the exhalent is frequently provided with a tongue-like process. The gelatinous or cartilaginous outer tunic is frequently stiffened by imbedded grains of sand; and the branchial chamber is usually small and poorly developed, with minute gill slits and no internal longitudinal bars. The tentacles are small and not numerous; the digestive tract is extended posteriorly to a considerable distance beyond the extremity of the branchial chamber; and budding takes place from the end of the postabdominal region. The family is represented by well nigh a score of genera, among which *Amarucium* may be selected as an example, on account of its numerous species. Here the colony is massive, being sometimes lobed or stalked; the mode of arrangement is usually compound and irregular; and the individuals are elongated, with six lobes to the inhalent orifice, and the postabdominal region elongated. The species figured on p. 2946 (*A. densum*) is from Northwestern Europe, and is characterized by its grayish yellow color, and the abundance of sand in the tunic; but other kinds may be black, orange, or rosy red, or white. In our figure, *a* shows fully active individuals; while those in the outer ring indicated by *b* assume a kind of torpid condition during the winter, but give rise to fresh buds in the spring.



AN INCRUSTING ASCIDIAN (*Botrylloides*) ON A SEA-WEED.

(Natural size.)

Omitting mention of the remaining families of the group just considered, we come to the third and last suborder of the typical ascidians, namely, the phosphorescent ascidians,—A. Luciæ. These are represented solely by the genus *Pyrosoma*, which is thus the only member of the family *Pyrosomatidæ*. These ascidians are free swimming pelagic forms, reproducing by buds in such a manner as to form colonies in the shape of a sac; such colonies sometimes attaining huge dimensions. In the sac thus formed the constituent individuals are imbedded in such a manner that all their inhalent apertures open on its outer surface, while their exhalent orifices are situated within the cylinder; the mouth of the sac forming the common discharging aperture. The apertures of the units are not lobed; and the outer tunic is gelatinous and transparent, containing no hard spicules, but provided with numerous minute cells. The branchial chamber is well developed, and the tentacles are simple. The first four individuals of the colony grow in the form of buds from a rudimentary sexually-developed larva; the subsequent increase taking place by budding from a ventral posterior stolon. The genus is represented only by four species, in one of which (*P. elegans*) the individuals form regular oblique rows in the walls of the sac, while in the other three they are arranged irregularly. The largest of all is *P. spinosum* from the Atlantic, in which the total length of the colony may be upward of four feet; this species being distinguished by the surface of the sac being provided only with short sharp spines, instead of with large processes of the tunic. It is to these ascidians that the most beautiful phosphorescence of tropical seas is due, each colony, when stimulated by a touch or shake of the water, giving forth a brilliant ball of bluish light, which lasts for several seconds, as the organism floats along beneath the surface, and then suddenly disappears. A colony is figured on p. 2954.



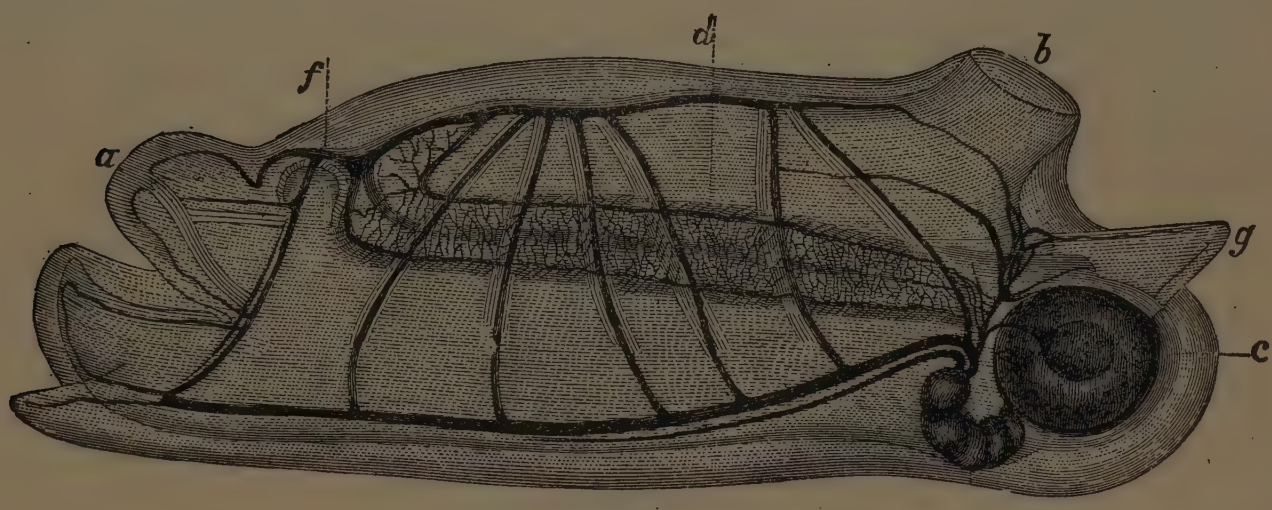
A COMPOUND ASCIDIAN (*Amarucium*) IN WINTER CONDITION.
(Natural size.)

Describing the luminosity produced by these ascidians, Bennett states that on one occasion in the Australian seas, when he reached the deck, he observed a "broad and extensive sheet of phosphorescence, extending in a direction from east to west, as far as the eye could reach. The luminosity was confined to the range of animals in this shoal, for there was no similar light in any other direction. I immediately cast the towing net over the stern of the ship, as we approached nearer the luminous streak, to ascertain the cause of this extraordinary and so limited phenomenon. The ship soon cleaved through the brilliant mass, from which, by the disturbance, strong flashes of light were emitted; and the shoal, judging from the time the vessel took in passing through the mass, may have been a mile in breadth. The passage of the vessel through them increased the light around to a far stronger degree, illuminating the ship. On taking in the towing net, it was found half filled with *Pyrosoma*, which shown with a pale, greenish light; and there were also a few shellfish in the net at the same time. After the mass had been passed through, the

light was still seen astern, until it became invisible in the distance." Frequently the phosphorescence is intermittent, periods of luminosity alternating with intervals of darkness. Moseley writes that during the voyage of the *Challenger*, "a giant *Pyrosoma* was caught by us in the deep-sea trawl. It was like a great sac, with its walls of jelly about an inch in thickness. It was four feet in length, and ten inches in diameter. When a *Pyrosoma* is stimulated by having its surface touched, the phosphorescent light breaks out at first at the point stimulated, and then spreads over the surface of the colony as the stimulus is transmitted to the surrounding animals. I wrote my name with my finger on the surface of the giant *Pyrosoma*, as it lay on deck in a tub at night, and my name came out in a few seconds in letters of fire."

Non-Luminous Pelagic Ascidians

With the exception of the family just mentioned, and also of a second one which constitutes the third order, the present ordinal group — termed the Thaliacea — includes the whole of the free swimming pelagic representatives of the class. Either simple or compound in structure, these ascidians lack both a tail and a notochord in the adult, but have a



AN INDIVIDUAL OF A CHAIN SALPA.
(Natural size.)
a. inhalent, and *b.* exhalent, orifice; *d.* gill; *c. e.* viscera; *f.* eye (?); *g.* pedicle of union.

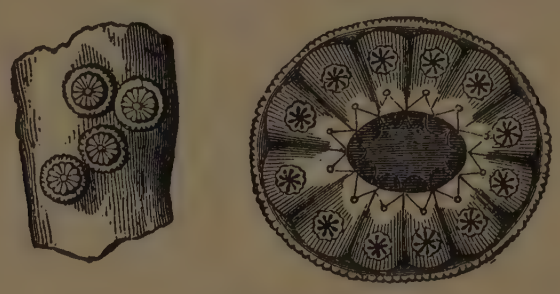
persistent outer tunic, which may be either feebly or fully developed. In the inner tunic the muscles are arranged in the form of more or less nearly complete circular bands, the contraction of which forms the motive agency of the creatures. The branchial chamber has either two large openings, or a number of smaller gill slits, leading to a single atrial cavity; the latter communicating with the exterior by the exhalent aperture, and the vent opening within it. In all the members of the group an alternation of generations takes place; and this may be further complicated by the individuals of a single generation being unlike one another. During one period of existence temporary colonies may be formed, but these never increase by the budding of the constituent units, which eventually separate from one another and disperse.

The well-known salpæ form a suborder — Hemimyaria — characterized by the formation of temporary colonies in the sexual generation, and represent a family (*Salpidæ*) distinguished by the muscular bands of the inner tunic being incomplete

on the lower surface of the body. Pelagic in habit, and transparent in structure, salpæ have been not inaptly compared to a barrel with both ends knocked out; and really consist of little more than a huge pharynx, swimming through the water, and taking in large mouthfuls of the same at each contraction of its muscles. Through the hollow, to below the hinder aperture, runs obliquely a rod-like gill (*d*) from above the mouth, although this is too narrow to interfere with the free flow of the water; while the lower surface of the interior of the creature is furnished with a ciliated slime-secreting band, corresponding to the structure known in other ascidians and the lancelet as the endostyle. It may here be well to mention that in the lancelet the structure in question is an elongated gland situated at the base of the pharynx, and against which the ends of the gill bars abut. The only part of the salpa that is not transparent is the thick mass of viscera (*e*, *c*) at the hinder end of the body; while the muscular bands, by the contraction of which the water is driven through the barrel, may be compared to the hoops of the latter. Externally the whole animal is invested with a thick, tough, transparent tunic; and in some forms there are two tail-like appendages to the hinder end of the body. Such is the structure of a salpa; but there are two generations in the life of these creatures, namely, the simple form, and the chain-like or aggregate form; the first being shown in the upper, and the second in the lower figure of the plate facing p. 2938. It will be observed that in the chain the individuals are attached to one another by their upper and lower surfaces, and thus have these two apertures free; and when taken from the water the whole chain, which is several feet in length, can be easily resolved into its component units. The specimen represented in the figure on p. 2947 is one of these detached units from a chain, the projection marked *g* being for the purpose of attachment to the neighboring individual. Although extremely interesting and curious, the whole history of the development of salpæ is so complicated that it is almost impossible to explain it fully in a popular work. It may be stated, however, that the solitary salpa is born from an egg carried within the body of one unit of the aggregate form, the embryo being nourished by means of a placenta from the blood of the parent. On the other hand, the chain salpæ are produced asexually by budding from a stolon within the body of the solitary form. In the chain salpa the eggs arise, however, at an exceedingly early period of its development, with the curious result that three generations are present at one time in a single individual. Thus a solitary salpa has within it the buds of an aggregate salpa, the units of which may each contain eggs which will ultimately develop into the next solitary form. And, as a matter of fact, in a solitary salpa the germ cells of the embryo of the next solitary form are actually visible before the development of the stolon which is to give rise to the chain form. As the stolon forms in the body of the latter, it includes within it the mass of germinal cells; and while the former elongates to form the chain of units, the mass of germ cells likewise lengthens, with the result that a single egg cell is shut off in each unit of the chain. Simple salpæ vary in size from a quarter of an inch to upward of eight inches; and in some parts of the ocean surface are met with in incalculable swarms. Although more abundant in tropical than in the cooler seas, their northward range extends beyond Scotland and Norway, while to the south they have been taken below the

latitude of Cape Horn and the most southern point of Australia. Dr. Brooks writes that "they are abundant only after the water has been for some time undisturbed by winds; and as prolonged calms are most frequent in warm seas, those waters are most favorable for the developement of these animals, which multiply with most astonishing rapidity. The smaller species are often so abundant that for hundreds of miles any bucketful of water dipped up at random, will be found to contain hundreds of them. In such places collecting with the surface net becomes impracticable, for almost as soon as the net is dropped into the water, it becomes chocked with a mass so dense that nothing can enter it." The food of these creatures consists of minute marine organisms, both animal and vegetable. In swimming, chain salpæ progress by an undulating, snake-like movement. Usually, the family is divided into the two genera *Salpa* and *Cyclosalpa*, the latter being distinguished by having the digestive tract coiled up; but some writers have divided the first of these two into several subgeneric groups. A second family is represented by the very imperfectly known genus *Octacnemus*, dredged at depths of between one and two thousand fathoms in the South Pacific; the body being much flattened, and probably attached by one extremity. Nothing is known as to the life history of this singular form.

The second suborder — Cyclomyaria — of the free swimming nonluminous ascidians takes its name from the muscular bands of the inner tunic forming perfect rings,



Botryllus.
(Natural size and enlarged.)

and is typically represented by the genus *Doliolum*. The life history is complicated by polymorphism; the tailed larva developing into a sexless form, the buds from which give rise to nutritive units, fostering units, and reproductive units. In the typical genus all the muscles form encircling hoops, and the three forms of the sexual generation occur together on one stolon, or outgrowth; but in *Anchinia* there are only two complete muscular rings, and the three forms of the sexual generation are produced successively.

Tailed Ascidians

The free swimming form known as *Appendicularia* is the type of the third and last order — Larvacea — of the class, all the members of which are characterized by the possession in the adult state of large tail-like appendages, furnished with a skeletal axis. These creatures, which are of minute size, have not undergone the degeneration so noticeable in the adult of the other tunicates, and thus correspond much more closely to the larval stage of the latter. A curious feature is the rapid production of a temporary outer tunic, which may be shed at any time, and replaced by a second one. There is no separate atrial cavity;

and the branchial chamber is simply an elongated pharynx, with two openings on the lower surface, which correspond to the gill slits, and are well furnished with cilia. The nervous system consists of a large ganglion placed in the anterior part of the dorsal surface, followed by a long chord, provided with smaller ganglia, and extending backward over the intestine to reach the tail, where it runs along the left side of the skeletal axis. The intestine itself is situated behind the branchial chamber, and the vent opens on the inferior or ventral aspect of the body in advance of the gill slits. Neither budding, metamorphosis, nor alternation of generations takes place; and the reproductive organs are situated at the hinder end of the body. The group comprises only the single family *Appendiculariidæ*, which contains five genera, the names and characteristics of which it will be unnecessary to mention.

CHAPTER V

THE WORM-LIKE PROTOCHORDATES—CLASS Enteropneusta

Balanoglossus

THE last, and at the same time the lowest, group of the Protochordates is typically represented by the marine *Balanoglossus*. Living buried in the sand or mud of the seashore, these worm-like creatures exhale a peculiar odor resembling that of the chemical substance termed iodoform, and secrete a copious supply of slime, to which adhere particles of sand, thus forming a protective tube for their bodies. At the front extremity of the creature, writes Mr. Willey, "there is a long and extremely sensitive proboscis, which is capable of great contraction and extension, and is in the living animal of a brilliant yellow or orange color. Behind the proboscis follows a well-marked collar region, consisting externally of a collar-like expansion of the integument, with free anterior and posterior margins overlapping the base of the proboscis in front and the anterior portion of the gill slits behind. (The gill slits are seen in our illustration below the collar.) In the ventral middle line, at the base of the proboscis, and concealed by the collar, is situated the mouth. Following behind the collar is the region of the trunk or body proper, which, in the adult of some species, reaches a relatively enormous length, even extending to two or three feet. The ectodermal covering of the body consists in general of ciliated cells, among which are scattered unicellular mucous glands; the cilia, however, appear to be more prominent on the proboscis than elsewhere. In the region of the trunk, which immediately follows upon the collar region, there are a great number of paired openings on the dorsal side of the body placing the anterior portion of the digestive tract in communication with the outer world. These are the gill slits, and they are arranged strictly in consecutive pairs to the number of upward of fifty in the adult. In their structure, and more especially in the possession of tongue bars, they bear a remarkable resemblance to the gill slits of the lancelet. This is particularly striking in young individuals. As the adult form is approached in the development, the bulk of the gill slits



A YOUNG BALANOGLOSSUS.
(Much enlarged.)

sinks below the surface, only opening at the latter by small slit-like pores, and thus their true characteristic is obscured in superficial view." On dissection, a rod-like structure, which arises as an outgrowth of the alimentary canal above the mouth, is seen projecting into the interior of the proboscis; and this rod has been identified with the vertebrate notochord. Above this rod, and extending farther back, is a dorsal nerve chord, corresponding to the vertebrate nerve tube, and having, as in the latter, a central canal, at least during the earlier stages of growth. Some distance behind the notochord this nerve tube gives off a descending branch, connecting it with a similar chord lying on the ventral aspect of the animal.

We thus have evidence of the existence in this strange worm-like creature of three essentially vertebrate characteristics, namely, gill slits, a notochord, and a nerve tube; and it is not a little remarkable that while in the sea squirts the notochord is found in the transitory tail, in *Balanoglossus* it is situated in the anterior extremity, where it extends some distance in advance of the mouth. Quite recently it has been shown that the tornaria larva of one species of *Balanoglossus* also possesses an endostyle (see p. 2948), comparable to that of the lancelet and sea squirts. That the creature under consideration is closely allied to the other Protochordates, and thus to the Vertebrates, may be considered fairly certain; but there are also indications of affinity with Nonchordates. In the first place, while certain species of *Balanoglossus* pass through the earlier stages of their existence without undergoing a metamorphosis, in other kinds such a transformation takes place; the young making its first appearance in the world in the form of what is known as a tornaria larva, or one closely resembling that of a starfish. And it is held by competent naturalists that this resemblance must be indicative of some kind of genetic relationship between *Balanoglossus* on the one hand, and starfish and sea urchins on the other. In the second place, there are not wanting indications of affinity with the so-called Nemertine worms, described in the next volume; these resemblances presenting themselves in the structure of the outer layer of the skin, the presence of a proboscis (kept retracted in the Nemertines), as well as in regard to the nervous system, the reproductive organs, and the alimentary canal.

Other Forms

The two other forms included among the Protochordates are respectively known as *Cephalodiscus* and *Rhabdopleura*, and bear the same relation to the last as is presented by the compound ascidians to the lancelet. Both these curious creatures are fixed forms, living in societies, reproducing their kind by means of buds, and having a U-shaped, instead of a straight, intestine. Both are likewise deep-water creatures, the former having been dredged in the straits of Magellan at a depth of two hundred and forty-five fathoms, while the latter has been taken off the Shetlands in ninety, and off the Lofoten islands in two hundred fathoms. Extremely minute in size, *Cephalodiscus* lives in colonies, the individuals wandering about the tubes of a common house, the walls of which are composed of a gelatinous material, covered with spiny projections, and perforated by numerous apertures for the free circulation of water. The mouth is overhung by a large shield-like plate, surmounted by the row of plume-like tentacles; while on the side of the body is a pedicle from which grow the buds; locomotion being probably ef-

fected by means of this pedicle and the mouth plate. The latter contains a short notochordal rod; and there is a single pair of gill slits opening from the pharynx, water being passed into this from the mouth by the action of the tentacles. In the allied genus *Rhabdopleura* the individuals which go to form a colony are connected with one another by means of a common stem, representing the remnants of their original contractile stalks; this stem gradually drying up with the growth of the colony in the region most remote from the living polyps. Each polyp has but a single plume-like tentacle; and the buds arising from the soft part of the common stem never become detached. While the nervous system and notochord are essentially the same as in *Cephalodiscus*, gill slits are wanting.

Ancestry of Chordates

Before making a few brief remarks on this interesting but perplexing subject, it may be mentioned that while we have no satisfactory clue as to the first origin of the notochord, it has been suggested that the original function of gill slits was to carry off the superfluous water entering the mouth with the food; the connection with respiration being a later addition to these structures. It is also an important factor in the consideration of this subject to bear in mind that the whole of the existing Protochordates are to a greater or less extent degenerate types, although they doubtless retain some original and simple primitive features. For the proud position of the original ancestral stock, from which have sprung both Protochordates and Vertebrates, there are many claimants; among these being segmented worms or annelids, creatures allied to the existing king crab, and starfishes and sea urchins. With regard to the annelid theory, Mr. Willey very significantly remarks that in this case the doctrine of parallelism in development has not been sufficiently taken into account; and that the more complete the superficial resemblance between an Annelid and a Vertebrate, in the same measure is the parallelism in their developmental history the more striking, and their genetic affinity the more remote. Neither is it likely that the king crab line of descent (in spite of the apparent identity in the structure of one layer of its shell with that of the Cephalaspidians) will hold good. The evidence in favor of an alliance between Vertebrates and Echinoderms (sea urchins and starfishes), through the intervention of *Balanoglossus*, seems, however, to be steadily gaining ground. Mr. Willey, for instance, remarks that while it is probable that the proximate ancestor of the Vertebrates was a free swimming creature, intermediate in structure between an ascidian larva and the lancelet, the ultimate or primordial ancestor may be assumed to have been a worm-like animal, with an organization approximately on a level with that of the bilaterally symmetrical progenitors of the Echinoderms. Mr. Garstang also, having proved that the larvæ of the whole of the latter group can be derived from a single common type, and likewise having shown that the tornaria larva of *Balanoglossus* can be referred to the same modification, expressed an opinion that the Vertebrates also trace their origin to the same free swimming pelagic form. Perhaps still more probability may attach to a later theory of the same observer, who now comes to the conclusion that Echinoderms, Enteropneusta, and Chordates are all divergent branches from a common unknown ancestor; such ancestor being a bilaterally symmetrical creature with the general appearance of a certain type (*Auricularia*) of Echinoderm larva. From the hypothetical common stock the

Echinoderms appear to have been derived by a series of changes mainly correlated with the assumption of their characteristic radial symmetry; while the Chordates retained the original bilateral symmetry, at the same time undergoing certain changes, into the consideration of which it will be unnecessary to enter in this place. Still more complicated are the changes necessary to evolve *Balanoglossus* and its allies from the ancestral form. Such of our readers as are desirous of pursuing further this interesting subject, may be referred to the works of the observer last mentioned.



A PYROSOMA COLONY.
In life the colony assumes a horizontal position.

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